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Volume 11 SEPTEMBER, 1937 Number 6

JOURNAL OF PALEONTOLOGY

A Publication of
The Society of Economic Paleontologists and Mineralogists
A Division of the American Association of Petroleum Geologists
and
The Paleontological Society
An Associate of the Geological Society of America

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JOURNAL of PALEONTOLOGY

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The JOURNAL OF PALEONTOLOGY is published semi-quarterly by the Society of Economic Paleontologists and Mineralogists, a division of the American Association of Petroleum Geologists, and by the Paleontological Society, associated with the Geological Society of America.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Puerto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Single numbers, $2.00 each.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20), and for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and non-receipt of preceding numbers should be addressed to Society of Economic Paleontologists and Mineralogists, P. O. Box 1852, Tulsa, Oklahoma. Claims for non-receipt of preceding numbers must be sent in within three months of the date of publication in order to be filled gratis. Communications in regard to advertising should be addressed to Henry V. Howe, Louisiana State University, Baton Rouge, Louisiana.

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Entered as second-class matter at the Post Office at Fort Worth, Texas, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 6, PP. 479–512, PLS. 56, 57, SEPTEMBER, 1937

GASTROPODS OF THE FAMILY EPITONIIDAE FROM MESOZOIC AND CENOZOIC ROCKS OF THE WEST COAST OF NORTH AMERICA, INCLUDING ONE NEW SPECIES BY F. E. TURNER AND ONE BY R. A. BRAMKAMP

J. WYATT DURHAM

An effort is made in this paper to bring together all known members of the family Epitoniidae from Mesozoic and Tertiary rocks of the west coast of North America, referring them to proper genera and subgenera. All available material has been examined and classified. Specimens not previously named have been described as new species, although a few are based on poor material. This is justified by the fact that each species is very distinctive, and all important characters for differentiation are present. Numerous fossil and recent species on the west coast have been described without adequate figures, description, or well-preserved types.

CHARACTERS OF THE EPITONIIDAE

Gastropods belonging to the family Epitoniidae (=Scalaridae =Scalidae) are characterized as follows: Shell usually colorless, more or less turreted, often umbilicate, possessing axial ribs or varices (both sometimes nearly obsolete); spiral ribs or striae may be present; aperture entire, rounded, circular or oval, (inner lip is often reduced to a thin band of callus); whorls numerous, usually convex, either loosely or tightly coiled; operculum horny, paucispiral. Foot short, truncated in front, extending far in advance of head; eyes on outer side, close to base of tentacles which are long, narrow, and close together; mantle margin simple, with a rudimentary siphonal fold; jaws oval or semicircular, spiny, or denticulated only on margin; radula wide, more or less bent at ends; teeth elongate unciform, or aciculated, many in a series; gonads protandrously hermaphroditic; predaceous. (Data regarding soft parts are compiled from Tryon, 1887, p. 49, and Thiele, 1929.)

According to Cossmann (1912, p. 97), *Proacirsa* of the Lower Jurassic is the earliest subgenus of this family to appear. Tryon (1887, p. 49) and Dall (in Zittel, 1913, p. 538) consider *Epitonium* (*sensu lato*), which includes all the genera here discussed, as ranging from the Triassic to Recent. The oldest species included in this paper is *Opalia* (*Claviscala*) *dispar* (Gabb) from Horsetown beds (commonly considered as Lower Cretaceous) from the upper end of the Sacramento Valley.

The Epitoniidae are found from low tide to depths of 805 fathoms (Dall, 1889, p. 316), usually on sandy bottoms. Most of the species live in depths of less than 100 fathoms, while some subgenera live at greater

depths in tropical waters. A great variety of species, few in individuals, is found in all seas. The larger and more magnificent species are usually found in tropical waters, where *Sthenorytis* goes down to deep water (805 fathoms) and *Claviscala* comes from "abyssal depths."

Epitonium (=*Scalaria*=*Scala*) has been used in the past by some authors to include all the various groups here included in the family Epitoniidae. Or, as by Cossmann and others, this group has been divided into subfamilies, abundant genera, and innumerable subgenera and sections. Most of the subgenera and sections of de Boury and Cossmann can be recognized by careful investigators and are probably valid biological units, but it appears that most of the genera defined by Cossmann should be reduced to subgeneric ranks. According to modern concepts, however, certain groups should be recognized as genera. Species representing four of these genera,—*Epitonium* Bolten (emend.), *Opalia* H. and A. Adams, *Acrilla* H. Adams, and *Acirsa* Mörch,—are included in the present work.

Thin sections of the shell of species of all the above genera except *Acirsa* have been studied. Preliminary results indicate that such sections may be used to advantage in determining correct generic assignments of species.

Characters of most value in discrimination of species are: arrangement of the spiral ribs as to number, size, and spacing; arrangement of punctuations in punctuate groups; character and average number of axial ribs and varices (when spiral ribs are absent). One must note, however, that where number of varices and axial ribs is greatest, variation in species is also greatest (for example, in *Epitonium* (*Boreoscala*) *condoni* Dall the varices vary from 10 to 21, average about 15), and where the average number is least, variation is least. Other characters of value are: average angle of the spire; number of whorls in mature specimens; presence of an umbilicus; presence of coronating points on the varices; and curvature of the growth lines.

In this paper U. C. indicates California Univ. Mus. Paleontology; C. A. S., California Acad. Sci.; U. W., Washington Univ. Paleont. Coll; L. S. J. U., Stanford Univ. Paleont. Type Coll.; N. P. for the Northern Pacific collection of Stanford University made by Hannibal and Arnold.

I am much indebted to Dr. Bruce L. Clark, University of California, under whose direction the study was made; to Dr. Richard A. Bramkamp, formerly of the Museum of Paleontology, University of California; and to Dr. H. G. Schenck, Stanford University, for helpful advice and criticism. Doctor Schenck, Dr. L. G. Hertlein of the Department of Paleontology, California Academy of Sciences, and Dr. Charles E. Weaver, University of Washington, have kindly loaned material from the collections under their care. Finally, I express appreciation to my wife, Jane Roberts Durham, for assistance in the correction of the manuscript.

DISTRIBUTION OF THE EPITONIIDAE

Attempt is made in the following list, showing distribution of species

of the Epitoniidae, to follow commonly accepted age assignments of various formations on the west coast. In some cases it has been necessary to be rather arbitrary in the age assignments. Abbreviations used are as follows:

HT—Horsetown series, Lower Cretaceous.
UC—Upper Chico formation, Upper Cretaceous.
ME—Martinez formation, lowermost Eocene.
CD—Capay and Domengine formations, Middle Eocene.
TE—Tejon, Coaledo, and Cowlitz formations, Upper Eocene.
KG—Keasey and Gries Ranch formations and other west coast strata having a fauna similar to one or the other, "Lower Oligocene."
LO—Lincoln formation (type) of Washington and west coast strata approximately equal in age, "Middle" Oligocene.
BO—Blakeley formation (type), Twin Rivers formation, and other west coast strata of approximately the same age, "Upper Oligocene."
VM—Vaqueros formation, and strata commonly mapped as Vaqueros in California, Lower Miocene.
TM—Temblor formation of California, Astoria formation of Oregon and Washington, and strata commonly correlated with them, Middle Miocene.
SP—San Pablo series of California and strata commonly correlated with it, Upper Miocene
PL—San Diego, Etchegoin, Wildcat, Empire, upper Montesano, and other formations commonly considered to be Pliocene.

Species of Epitoniidae from the West Coast of North America, Showing Stratigraphic Distribution

	HT	UC	ME	CD	TE	KG	LO	BO	VM	TM	SP	PL
Epitonium (Gyroscala) effingeri Durham, n. sp.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (Clathrus) weaveri Durham, n. sp.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (Nitidiscala) indianorum Carpenter	—	—	—	—	—	—	—	—	—	×	—	×
Epitonium (Nitidiscala) contrerasi Jordan and Hertlein	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Nitidiscala) cooperi Strong	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Nitidiscala) eelense Durham, n. sp.	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Nitidiscala) tinctum (Carpenter)	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Asperiscala) cedrosensis Jordan and Hertlein	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Asperiscala) dallasi Jordan and Hertlein	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Asperiscala) hemphilli (Dall)	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Crisposcala) efferum Bramkamp, n. sp	—	—	—	—	—	—	—	—	—	?	—	—
Epitonium (Cirsotrema) clallamense Durham, n. sp.	—	—	—	—	—	—	×	—	—	—	—	—
Epitonium (Cirsotrema) saundersi Tegland	—	—	—	—	—	—	—	×	—	—	—	—
Epitonium (Cirsotrema) posoense Anderson and Martin	—	—	—	—	—	—	—	—	—	×	—	—
Epitonium (Cirsotrema) howei Durham, n. sp.	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (Cirsotrema) n. sp. A	—	—	—	—	—	—	—	—	—	×	—	—
Epitonium (Cirsotrema) n. sp. B	—	—	—	—	×	—	—	—	—	—	—	—
Epitonium (Boreoscala) earlturneri Durham, n. sp.	—	—	—	—	×	—	—	—	—	—	—	—

Species of Epitoniidae from the West Coast of North America, Showing Stratigraphic Distribution (Continued)

	HT	UC	ME	CD	TE	KG	LO	BO	VM	TM	SP	PL
Epitonium (*Boreoscala*) *insecuritum* Hanna	—	—	—	—	×	—	—	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* Dall	—	—	—	—	—	×	×	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* var. *eugenense* Durham, n. var.	—	—	—	—	—	—	×	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* var. *hadlockense* Durham, n. var.	—	—	—	—	—	—	×	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* var. *oregonense* Dall	—	—	—	—	—	×	×	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* var. *quimperense* Durham, n. var.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* var. *townsendense* Durham, n. var.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* var. *woodmanense* Durham, n. var.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* subsp. *janerobertsae* Durham, n. subsp.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* subsp. *refulleri* Durham, n. subsp.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *wagneri*, Durham, n. sp	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *keaseyense* Durham, n. sp.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *keaseyense* subsp. *schencki* Durham, n. subsp.	—	—	—	—	—	×	—	—	—	—	—	—
Epitonium (*Boreoscala*) *greenlandicum* (Perry)	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (*Boreoscala*) cf. *greenlandicum* (Perry) Clark	—	—	—	—	—	—	—	×	—	—	—	—
Epitonium (*Boreoscala*) *coosense*, Durham, n. sp.	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (*Boreoscala*) n. sp. A.	—	—	—	—	—	—	—	—	×	—	—	—
Epitonium (*Sthenorytis*) *stearnsii* (Dall)	—	—	—	—	—	—	—	—	—	—	—	×
Epitonium (*Sthenorytis*) *toroense* Dall	—	—	—	—	—	—	—	—	—	—	—	?
Epitonium (*Sthenorytis*) *crescentense* Durham, n. sp.	—	—	—	—	—	?	—	—	—	—	—	—
Epitonium (*Sthenorytis*) *ventricosum* Clark	—	—	—	—	—	—	—	×	—	—	—	—
Opalia (*Opalia*) *rugifera* (Dall)	—	—	—	—	—	×	—	—	—	—	—	—
Opalia (*O.*) *bravinderi* Durham, n. sp.	—	—	—	—	—	—	—	×	—	—	—	—
Opalia (*O.*) *wroblewskyi* (Mörch)	—	—	—	—	—	—	—	—	—	—	×	×
Opalia (*O.*) *wishkahensis* Durham, n. sp.	—	—	—	—	—	—	—	—	—	—	—	×
Opalia (*O.*) *varicostata* Stearns	—	—	—	—	—	—	—	—	—	—	—	×
Opalia (*O.*) *varicostata* var. *anomala* Stearns	—	—	—	—	—	—	—	—	—	—	—	×

Species of Epitoniidae from the West Coast of North America, Showing Stratigraphic Distribution (Continued)

	HT	UC	ME	CD	TE	KG	LO	BO	VM	TM	SP	PL
Opalia (O.) varicostata var. *granti* Durham, n. var.	—	—	—	—	—	—	—	—	—	—	—	×
Opalia (Claviscala) dispar (Gabb)	×	—	—	—	—	—	—	—	—	—	—	—
Opalia (Claviscala), Durham n. sp.	—	×	—	—	—	—	—	—	—	—	—	—
Opalia (Confusiscala) mathewsonii (Gabb)	—	×	—	—	—	—	—	—	—	—	—	—
Opalia (Confusiscala) mathewsonii (Gabb) (?)	—	×	—	—	—	—	—	—	—	—	—	—
Opalia (Dentiscala) insculpta Carpenter	—	—	—	—	—	—	—	—	—	—	—	×
Opalia (Nodiscala) retiporosa Carpenter	—	—	—	—	—	—	—	—	—	—	—	×
Opalia (Rugatiscala) cowlitzensis Durham, n. sp.	—	—	—	—	×	—	—	—	—	—	—	—
Opalia (Rugatiscala) williamsoni (Anderson and Martin)	—	—	—	—	—	—	—	—	—	×	—	—
Acrilla (Ferminoscala) aragoensis (Turner) Durham, n. sp.	—	—	—	—	×	—	—	—	—	—	—	—
Acrilla (Ferminoscala) tejonensis (Dickerson)	—	—	—	×	—	—	—	—	—	—	—	—
Acrilla (Ferminoscala) berthiaumei Durham, n.sp.	—	—	—	—	×	—	—	—	—	—	—	—
Acrilla (Ferminoscala) becki Durham, n. sp.	—	—	—	—	—	×	—	—	—	—	—	—
Acrilla (Ferminoscala) dickersoni Durham, n. sp.	—	—	—	—	—	×	—	—	—	—	—	—
Acrilla (Ferminoscala) lincolnensis (Weaver)	—	—	—	—	—	—	×	—	—	—	—	—
Acrilla (Ferminoscala) pinolensis (Clark)	—	—	—	—	—	—	×	—	—	—	—	—
Acrilla (Ferminoscala) atwoodi (Dall)	—	—	—	—	—	—	—	—	—	?	—	—
Acrilla (Ferminoscala) n. sp. A.	—	—	—	—	—	—	?	—	—	—	—	—
Acrilla (Undiscala) lolakensis Durham, n. sp.	—	—	×	—	—	—	—	—	—	—	—	—
Acrilla (Undiscala) washingtonensis (Weaver)	—	—	—	—	—	—	×	—	—	—	—	—
Acrilla (Undiscala) olympicensis Durham, n. sp.	—	—	—	—	—	—	—	×	—	—	—	—
Acirsa (Acirsa) vaquerosensis Durham, n. sp.	—	—	—	—	—	—	—	—	×	—	—	—
"*Scalaria*" *albensis* d'Orbigny, Anderson	×	—	—	—	—	—	—	—	—	—	—	—
"*Epitonium*" sp. undet. Clark	—	—	—	—	—	—	×	—	—	—	—	

KEY TO THE EPITONIIDAE

Key to Genera and Subgenera of Epitoniidae Included in This Paper

1—True varices present. Genus *Epitonium*

2—Spiral ribs present.

3—Basal disk present.

4—Surface of varices covered by network of crossed spiral lines producing a decussate appearance. Subgenus *Crisposcala*

4—Surface of varices not so covered.

5—Body whorl very large, spire low. Subgenus *Sthenorytis*

5—Body whorl not large, spire high.

6—Basal disk bounded by a continuous keel, varices simple.
Subgenus *Boreoscala*
6—Basal disk not bounded by a continuous keel but by short triangular posterior enlargements of the varices.
Subgenus *Cirsotrema*
3—Basal disk absent.
Subgenus *Asperiscala*
2—Spiral ribs absent.
3—Basal disk present.
Subgenus *Gyroscala*
3—Basal disk absent.
4—Varices continuous over all whorls. Subgenus *Clathrus*
4—Varices not continuous from whorl to whorl.
Subgenus *Nitidiscala*

1—Varices absent; (true axial ribs present).
2—Outer lip not sharp.
3—Axial ribs passing onto basal disk.
Genus *Acrilla*
4—Axial ribs usually not as heavy as spiral ribs; when they are as heavy they simulate varices.
Subgenus *Ferminoscala*
4—Axial ribs heavier than spiral ribs, not varix-like.
Subgenus *Undiscala*
3—Axial ribs not passing onto basal disk. Genus *Opalia*
4—Only very fine spiral striations present.
5—Suture deep and with a sharp angulation just below it, crenulated by upper margin of ill-defined axial ribs. Subgenus *Dentiscala*
5—Suture moderately deep, without a sharp angulation, not crenulated.
Subgenus *Opalia*
4—Spiral ribs present.
5—Distinct perforations in interspaces between spiral ribs.
Subgenus *Nodiscala*
5—Perforations not present.
6—Basal keel visible in suture.
7—Axial ribs continuous from suture to suture.
Subgenus *Confusicala*
7—Axial ribs not continuous from suture to suture.
Subgenus *Claviscala*
6—Basal keel not visible in suture.
Subgenus *Rugatiscala*
2—Outer lip sharpened, shell heavy.
Genus *Acirsa*,
Subgenus *Acirsa s.s.*

Glossary of Terms used in Key

Axial ribs: Axial ornamentation formed by thickening of growth laminae, usually at regular intervals; fibers of the laminae are always nearly radial to axis of coiling, coming to surface of shell at regular intervals, not only at ribs, but between them.

Basal disk: Some of the Epitoniidae have the basal part of body whorl set off from rest of whorl by a slightly raised line, an angulation, or an incised groove; in many cases the basal disk is thicker than the rest of whorl.

Basal keel: Usually a raised line on periphery of basal disk, but sometimes merely the angulation of the shell.

Heavy: Used somewhat flexibly; a shell 0.6 mm. thick in interspaces between varices and about 35 mm. high is heavy.

Large: A shell 10 mm. in diameter and 25 mm. in height represents about the lower limit of "large" as here used, but one must consider the genus (for example, in *Acrilla* diameter is less in proportion to height).

Small: A shell 6 mm. in diameter and 10 mm. in height is about the upper limit of small.

Thin: A rather flexible term; a shell 0.15 mm. thick in the interspaces and 15 mm. high is classed as thin.

Varices: Axial ornamentation composed of the ends of a number of growth laminae reflexed posteriorly, usually at regular intervals. The fibers of the laminae ordinarily nearly radial to the axis of coiling of the shell are approximately tangential to the

axis of coiling in the varices. No growth laminae come to the surface of the shell between varices.

SYSTEMATIC DESCRIPTIONS

Family EPITONIIDAE Dall, 1913

Genus EPITONIUM Bolten, 1798, emend. Durham

Plate 56, figure 1

Scala (Klein, 1753) BRUGUIERE, *1792*, p. 532 (no species cited).—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 25.—THIELE, *1929*, Hand. syst. Weichtier., p. 222.

Epitonium BOLTEN, 1798, Ms. Boltenianum, p. 91.—DALL, *1917*, U. S. Nat. Mus., Proc., vol. 53, p. 471.

not *Epitonium* LINK, *1807*.

Cyclostoma LAMARCK, *1799*, Prodrome, p. 74.

Scalaria LAMARCK, 1801, Syst. des Anim. sans Vert., p. 88.

Genotype: *Epitonium pretiosum* (LAMARCK) (=*Scalaria pretiosa* Lamarck =*Turbo scalaris* Linné). Recent, China Seas.

Shell turreted, porcellaneous and usually rather thin; whorls loosely or closely appressed; convex; with axial varices; aperture entire, usually ovate, slightly oblique, thickened by last varix; auricle present; spiral ribs present or none; umbilicus open or closed.

Thin sections of the shell of the genotype species and other species show two layers, the inner thin and composed of fine fibers perpendicular to the inner surface, the outer thicker and composed of growth laminae that pass from inside to outside of the layer in the distance of two varices in sections observed. All laminae terminate in varices where they are reflexed posteriorly, so that the fibers of the laminae, ordinarily nearly radial, are approximately tangential to the axis of shell coiling. There may be a slight break in normal continuity of the laminae at foot of varices, representing the resting stage in growth after formation of varices.

Paleocene to Recent.

Subgenus GYROSCALA de Boury, 1887

Gyroscala DE BOURY, 1887, Etude sous genres Scalidae, p. 15.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 46

Type: (original designation) *Epitonium comutatum* (Monts.), living in the Antilles.

Shell of medium size, rather thin; sutures moderately deep, whorls convex; ornamented by thin varices continuous from whorl to whorl; no spiral sculpture; basal disk present, limited by a peripheral keel; aperture ovate; inner lip very thin; auricle fairly prominent. Living in Caribbean and Oceanica.

Eocene to Recent.

EPITONIUM (GYROSCALA) EFFINGERI Durham, n. sp.

Plate 56, figure 25

Shell small, thin, slightly corroded, four convex whorls (incomplete); sutures broad, moderately deep; ornamented by 10 thin, knife-like varices continuous over all whorls; no extra callus deposited over base of preceding whorl at suture; basal keel slightly visible; no spiral sculpture apparent except for well-marked basal keel over which varices continue to aperture; aperture ovate.

Diameter of holotype, 6.1 mm.; height, 10.3 mm.; four whorls.

Remarks.—This species is named in honor of Mr. William Effinger whose monograph on the Gries Ranch fauna will soon appear. This distinctive species is the only *Gyroscala* known from Pacific Coast Tertiary beds.

Occurrence.—U. C., Loc. A-1809, lower Gries Ranch "Oligocene."

Holotype.—U. C., no. 30146.

Subgenus CLATHRUS Oken, 1815

Clathrus OKEN, *1815*, Lehrb. Zoologie, p. 256.—COSSMANN (part), *1912*, Essais paleoconch. comp., vol. 9, p. 36.

Type: (absolute tautonomy) *Epitonium communis* (Lamarck) (=*Turbo clathrus* Linné), Recent, Mediterranean, Atlantic.

Shell of medium size, thin; sutures deep, whorls well rounded, non-umbilicate; axial varices prominent, usually reflexed, continuous from whorl to whorl, united at sutures; no spiral sculpture, basal disk or keel; aperture ovate, a small anterior notched auricle; peristome

EXPLANATION OF PLATE 56

All figures natural size unless stated otherwise. U. C. indicates California Univ. Mus. Paleontology; C. A. S., California Acad. Sci.; U. W., Washington Univ. Paleont. Coll.

FIGS. *1*—*Epitonium pretiosum* (Lamarck), genotype of *Epitonium* Bolten. Hypotype, U. C., 30144. (p. 485)

2—*Opalia australis* (Lamarck), genotype of *Opalia* H. and A. Adams. Hypotype, U. C., 30145. (p. 500)

3—*Acrilla acuminata* (H. and A. Adams), genotype of *Acrilla* H. Adams, (Reproduction of pl. 25, fig. 130, Thes. Conchology, Sowerby, 1842). (p. 506)

4—*Acirsa borealis* (Beck), genotype of *Acirsa* Mörch, (reproduction of pl. 13, fig. 10, U. S. Nat. Mus., Bull. 112). (p. 510)

5—*Epitonium* (*Asperiscala*) *hemphilli* (Dall), ×2.375. Hypotype, U. C., 30148, San Diego Pliocene. (p. 490)

6—*Epitonium* (*Clathrus*) *weaveri* Durham, n. sp. Holotype, C. A. S., 7002, associated with a Keasey fauna, Holcomb, Wash. (p. 487)

7—*Epitonium* (*Nitidiscala*) *eelense* Durham, n. sp., ×6.19. Holotype, U. C., 30147. Pliocene, Eel River, Humboldt County, Calif. (p. 488)

8—*Epitonium* (*Cirsotrema*) *howei* Durham, n. sp. Holotype, C. A. S., 7004, Coos Bay Pliocene. (p. 492)

9—*Epitonium* (*Boreoscala*) *earlturneri* Durham, n. sp. Holotype, U. C., 30154. Coaledo formation, Eocene, Oregon. (p. 493)

10—*Epitonium* (*Crisposcala*) *efferum* Bramkamp, n. sp., ×2.4. Holotype, U. C., 30158. Imperial formation, middle or upper Miocene, California. (p. 490)

11—*Epitonium* (*Sthenorytis?*) *crescentense* Durham, n. sp. Paratype, U. C., 30165, lower Oligocene?, Port Crescent, Wash. Slightly distorted by crushing. (p. 500)

12—*Acirsa* (*Acirsa*) *vaquerosensis* Durham, n. sp., Holotype, C. A. S., 7011, Vaqueros "Miocene," California. (p. 511)

13—*Opalia* (*Opalia*) *bravinderi* Durham, n. sp., ×2.35. Holotype, U. C., 30167. Blakeley formation, Oligocene, Seattle, Wash. (p. 501)

14—*Epitonium* (*Nitidiscala*) *indianorum* (Carpenter), ×2.40. Hypotype, U. C., 30194, "Temblor," of Kern River. The aperture is incomplete and appears distorted. (p. 487)

15—*Epitonium* (*Sthenorytis?*) *crescentense* Durham, n.sp. Holotype, U. C., 30164, lower Oligocene?, Port Crescent, Wash. Showing suture. (p. 500)

16—*Acrilla* (*Undiscala?*) *olympicensis* Durham, n. sp. Holotype, U. C., 30185. Twin Rivers Oligocene, Washington. (p. 510)

17—*Opalia* (*Opalia*) *wishkahensis* Durham, n. sp. Holotype, C. A. S., 7008, Montesano formation, upper Miocene? or lower Pliocene, Washington. (p. 502)

18—*Acrilla* (*Undiscala*) *washingtonensis* (Weaver). Hypotype, U. C., 32431. Type Lincoln, Oligocene, Washington. (p. 510)

19—*Epitonium* (*Boreoscala*) *insecuritum* Hanna. Holotype, U. W., Cowlitz Eocene, Olequah Creek, Wash. (p. 493)

20—*Opalia* (*Claviscala*) *dispar* (Gabb). Plastotype, U. C., 30172, Horsetown beds, Lower Cretaceous, upper Sacramento Valley, Calif. A cast of the external mold of the type. (p. 503)

21—*Epitonium* (*Cirsotrema*) n. sp. *A*, Durham. Holotype, C. A. S., 7005, Temblor, Kern River, Calif. (p. 492)

22—*Acrilla* (*Undiscala*) *lolakensis* Durham, n. sp. Holotype, U. C., 30182, Martinez Eocene, Lower Lake, Calif. (p. 509)

23—*Opalia* (*Confusiscala*) *mathewsonii* (Gabb)?. Holotype, C. A. S., 7010, upper Chico, Siskiyou County, Calif. (p. 504)

24—*Acrilla* (*Ferminoscala*) *lincolnensis* (Weaver). Hypotype, U. C., 30168. Type Lincoln, Oligocene, Washington. (p. 508)

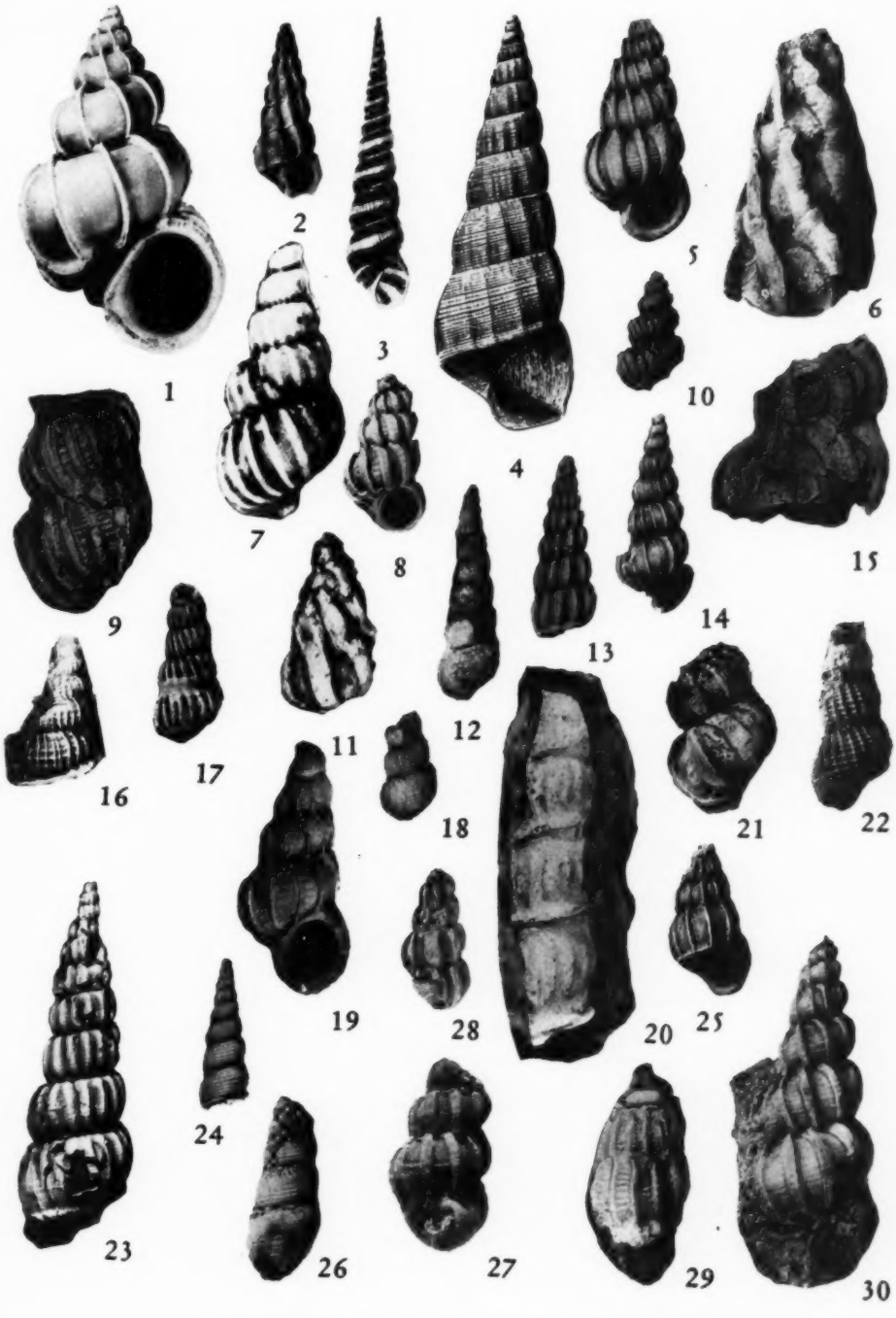
25—*Epitonium* (*Gryroscala*) *effingeri* Durham, n. sp., ×2.38. Holotype, U. C., 30146, type Gries Ranch, Oligocene?, Washington. (p. 485)

26—*Acrilla* (*Ferminoscala*) *becki* Durham, n. sp. Paratype, U. C., 30193. A large individual associated with a Gries Ranch fauna, Quimper Peninsula, Wash. (p. 507)

27, 28—*Epitonium* (*Cirsotrema*) *clallamensis* Durham, n. sp. *27*, Holotype, C. A. S., 7003. *28*, Paratype, U. C., 30170. Middle? Oligocene, Clallam Bay, Wash. (p. 491)

29—*Epitonium* (*Boreoscala*) *wagneri* Durham, n. sp. Holotype, U. C., 30159, San Emidgio formation, lower Oligocene, California. (p. 497)

30—*Epitonium* (*Boreoscala*) *coosense* Durham, n. sp. Holotype, C. A. S., 7007, Pliocene?, near Coos Bay, Ore. (p. 499)



Durham, Mesozoic and Cenozoic Gastropods

UNIV. OF MICH.

continuous, outer lip thickened by last varix. Living in Mediterranean, Atlantic, and Pacific oceans, in temperate and warm waters (Cossmann, 1912).

Eocene to Recent.

EPITONIUM (CLATHRUS) WEAVERI
Durham n. sp.
Plate 56, figure 6

Shell moderately large, rather thin; both the apex and body whorl broken off in type, leaving four incomplete whorls semicircular in outline; sutures rather deep; ornamented by six highly prominent knife-like varices strongly reflexed posteriorly; varices lapping about one-third height of preceding whorl onto the varices of that whorl, forming a continuous varix over all the whorls; no spiral ornamentation present.

Diameter of holotype, 20.8 mm.; height, 39.7 mm.; whorls (incomplete), 4.

Remarks.—The size and continuity of varices from whorl to whorl is very characteristic of this species.

Occurrence.—C. A. S., loc. 912, Holcomb, Wash., lower Oligocene, associated with Keasey fauna.

Holotype.—C. A. S., no. 7002.

Subgenus NITIDISCALA de Boury, 1909

Nitidiscala DE BOURY, *1909*, Jour. Conchology, vol. 57, p. 257.
Clathrus Oken, COSSMANN (part), *1912*, Essais paleoconch. comp., vol. 9, p. 36.
Type: (original designation) *Epitonium unifasciatum* (Sowerby). Recent, West Indies.

Shell small to medium; non-umbilicate, thin, sutures deep; axial varices prominent, not continuous from whorl to whorl, usually with spinose angulation just below suture and usually reflexed posteriorly; no spiral sculpture or basal disk; aperture ovate, both anterior and posterior auricles present. Living in Atlantic and Pacific in temperate seas, mostly in waters less than 100 fathoms deep, but down to 634 fathoms near Galapagos Islands (Dall, 1917, p. 482).

Miocene to Recent.

EPITONIUM (NITIDISCALA) INDIANORUM (Carpenter)

Plate 56, figure 14

Scalaria indianorum CARPENTER, *1864*, British Assoc. Adv. Sci., Rept. for 1863, p. 660; *1865*, Annals and Mag. Nat. History, ser. 3, vol. 15, p. 31.—TRYON, *1887*, Man. Conchology, ser. 1, vol. 9, p. 70, pl. 14, fig. 48.—COOPER, 1888, California State Mineralogist, 7th Ann. Rept., p. 263.
Scala indianorum Carpenter, WILLIAMSON, *1892*, U. S. Nat. Mus., Proc., vol. 15, p. 210.—ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 264, pl. 5, fig. 4.
Epitonium (*Scala*) *indianorum* Carpenter, MARTIN, *1916*, California Univ., Dept. Geol. Sci., Pub., vol. 9, p. 257.
Epitonium indianorum Carpenter, MARTIN, *1916*, California Univ., Dept. Geol. Sci., Pub., vol. 9, p. 239.—I. S. OLDROYD, *1924*, Washington Univ., Puget Sound Biol. Sta., Pub., vol. 4, p. 107.
Nitidoscala indianorum Carpenter, DALL, *1921*, U. S. Nat. Mus., Bull. 112, p. 115.
Epitonium (*Nitidiscala*) *indianorum* Carpenter, T. S. OLDROYD, *1925*, U. S. Nat. Mus., Proc., vol. 65, art. 22, p. 13.—I. S. OLROYD, *1927*, Stanford Univ., Dept. Geology, Pub., vol. 2, pt. 2, p. 57.—WATERFALL, *1929*, California Univ., Dept. Geol. Sci., Pub., vol. 18, p. 78.
Epitonium (*Nitidiscala*) *indianorum* (Carpenter), STRONG, *1930*, San Diego Soc. Nat. History, Trans., vol. 6, p. 192, pl. 20, figs. 1, 2*a*, 2*b*.—GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 859.

Specimens from Temblor beds apparently are not separable from the typical form except that one has only 10 varices.

Occurrence.—Type locality, Neah Bay, Wash., Recent.

Miocene: Kern River Temblor (U. C., loc. 2713).

Pliocene: "Pico form" near Ventura (Waterfall, 1929); Wildcat formation, Merced of Bolinas Bay and Ano Nuevo Bay (Martin, 1916); Coos Bay, Pliocene (C. A. S., loc. 14).

Pleistocene: "Pliocene" of Deadman Island (Timms Point "zone"), lower Pleistocene; common in the lower and upper San Pedro series of San Pedro and vicinity (Arnold); lower San Pedro series of Nob Hill cut, San Pedro, "not rare" (T. S. Oldroyd); "Saugus formation," near Ventura (Waterfall).

Recent: Forrester Island, Alaska, to Todos Santos Bay, Lower California, Mexico (Dall, 1921).

Types.—Holotype, U. S. Nat. Mus., no. 15521; hypotype, U. C., no. 30194.

EPITONIUM (NITIDISCALA) CONTRERASI
E. K. Jordan and Hertlein

Epitonium contrerasi E. K. JORDAN and HERTLEIN, *1926*, California Acad. Sci., Proc., ser. 4, vol. 15, p. 446, pl. 30, fig. 4.
Epitonium (*?Nitidiscala*) *contrerasi* E. K. Jordan and Hertlein, GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 858.

Occurrence.—Type locality, 1 mile southeast of Turtle Bay, Lower California, Mexico; Pliocene.

Type.—Holotype, C. A. S., no. 2121.

EPITONIUM (NITIDISCALA) COOPERI
Strong

Scala tincta Carpenter, ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 265, pl. 5, fig. 3 (not Carpenter, 1864).
Epitonium hindsii Carpenter, PACKARD, *1918*, California Univ., Pub. Zoology, vol. 14, p. 319, pl. 36, figs. 14*a*, 14*b*.
Epitonium fallaciosum Dall, JORDAN, *1926*, California Acad. Sci., Proc., ser. 4, vol. 15, p. 245.
Epitonium (*Nitidiscala*) *cooperi* STRONG, *1930*, San Diego Soc. Nat. History, Trans., vol. 6, pp. 189, 194, pl. 20, figs. 6*a*, 6*b*, 7, 8*a*, 8*b*.—GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 860.

Occurrence.—Type locality, San Pedro, Calif.; Recent.

?Pliocene: Pacific Beach and Russ School, San Diego (Arnold).

Pleistocene: Barlow's Ranch, Ventura (Arnold), equals Las Posas "zone"; rare in lower San Pedro; common in upper San Pedro, also at Pacific Beach and 26th Street, San Diego (Arnold); San Quintin Bay, Lower California (Jordan).

Recent: San Francisco Bay, Calif. (Packard in Strong), to the Gulf of California (?).

Types.—Holotype, San Diego Soc. Nat. History, no. 345; paratypes, U. S. Nat. Mus., nos. 46222, 56052.

EPITONIUM (NITIDISCALA) EELENSE
Durham, n. sp.
Plate 56, figure 7

Shell small, thin; about four postnuclear moderately convex whorls; sutures fairly deep; ornamented by 15 prominent, rather heavy varices that usually meet those of preceding whorl in the suture but do not fuse with them; some varices slightly reflexed posteriorly while others are not; a slight angle in varices just below suture makes an obscure coronation; varices ascending the spire in a line that is slightly spiral to the left; base of the body whorl slightly angulated almost forming a basal keel; aperture ovate, auricle rather prominent.

Diameter of holotype, 2.9 mm.; height, 6.6 mm.; whorls, 5 (one nuclear).

Remarks.—This species may be distinguished by the few whorls, approximately 15 varices, and by the ratio of diameter to height. It most nearly approaches *Epitonium* (*Nitidiscala*) *tinctum* in proportions, but has a greater number of varices and the aperture is wider at its base.

Occurrence.—Lower Pliocene, Eel River, Humboldt County, Calif.

Type.—Holotype, U. C., no. 30147.

EPITONIUM (NITIDISCALA) TINCTUM
(Carpenter)

Scalaria ? var. *tincta* CARPENTER, *1864*, British Assoc. Adv. Sci., Rept. for 1863, p. 660.
Scalaria (*?indianorum*, var.) *tincta* CARPENTER, *1865*, Annals and Mag. Nat. History, ser. 3, vol. 15, p. 31.
Scalaria subcoronata CARPENTER, *1866*, California Acad. Sci., Proc., vol. 3, p. 221.—COOPER, *1888*, California State Mineralogist, 7th Ann. Rept., p. 263.
Scala hindsii Carpenter, WILLIAMSON, *1892*, U. S. Nat. Mus., Proc., vol. 15, p. 209.—ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 264.—KEEP, *1911*, West Coast Shells, p. 183, fig. 174. Not Carpenter 1856, a Panama species.
Not *Scala tincta* Carpenter, ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 265. pl. 5, fig. 3.
Epitonium (*Nitidoscala*) *fallaciosum* DALL, *1917*, U. S. Nat. Mus., Proc., vol. 53, p. 478.—I. S. OLDROYD, *1927*, Stanford Univ. Dept. Geology, Pub., vol. 2, pt. 2, p. 59.

Nitidoscala subcoronata Carpenter, DALL, *1921*, U. S. Nat. Mus., Bull. 112, p. 115.
Nitidoscala tincta Carpenter, DALL, *1921*, *op. cit.*, p. 115.
Nitidoscala fallaciosa DALL, *1921*, *op. cit.*, p. 115.
Epitonium (*Nitidoscala*) *tinctum* Carpenter, T. S. OLDROYD, *1925*, U. S. Nat. Mus., Proc., vol. 65, art. 22, p. 13.—I. S. OLDROYD, *1927*, Stanford Univ. Dept. Geology, Pub., vol. 2, pt. 2, p. 58.
Epitonium fallaciosum Dall, E. K. JORDAN, *1926*, California Acad. Sci., Proc., ser. 4, vol. 15, p. 245.
Epitonium tinctum Carpenter, E. K. JORDAN, *1926*, *op. cit.*, p. 245.
Epitonium (*Nitidoscala*) *subcoronatum* Carpenter, I. S. OLDROYD, *1927*, Stanford Univ. Dept. Geology, Pub., vol. 2, pt. 2, p. 58.
Epitonium (*Nitidiscala*) *tinctum* (Carpenter), STRONG, *1930*, San Diego Soc. Nat. History, Trans., vol. 6, p. 193, pl. 20, figs. 3, 4, 5*a*, 5*b*.—GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 859.

Occurrence.—Type localities: of *tinctum*, San Pedro, Calif., Recent; of *subcoronatum*, Monterey, Calif., Recent; of *fallaciosum*, California, Recent.

Pliocene: San Diego well, Balboa Park, San Diego, middle Pliocene (Cooper, as *subcoronata*, probably also his record under *tinctum*); and U. C., loc. 5093, collected by M. A. Hanna.

Pleistocene: lower San Pedro series of Deadman Island and San Pedro (Arnold) as *fallaciosum* and *crebricostatum*); lower San Pedro series of Nob Hill cut, San Pedro (T. S. Oldroyd as *subcarinatum* and *tinctum*); Santa Barbara and San Pedro (Cooper, as *subcoronatum*, the Santa Barbara record possibly referring to the Santa Barbara "horizon," upper Pliocene); Barlow's Ranch near Ventura (Arnold); upper San Pedro series of Deadman Island and San Pedro; Pacific Beach and foot of 26th Street, San Diego (Arnold); upper Pleistocene at San Quintin Bay, Lower California, Mexico (Jordan), as *fallaciosum* and *tinctum*).

Recent: Vancouver Island, British Columbia, south to Lower California, probably to the Gulf of California.

Types.—Of *tinctum*, U. S. Nat. Mus., see discussion by Strong, 1930; of *subcoronatum*, probably U. S. Nat. Mus., 13830b, see discussion by Strong, 1930; of *fallaciosum*, U. S. Nat. Mus.

Subgenus ASPERISCALA de Boury, 1909

Asperiscala DE BOURY, *1909*, Jour. Conchology, p. 258.—COSSMANN, *1912*, Essais Paleoconch. Comp., vol. 9, p. 27.
Type: (original designation) *Epitonium bellastriatum* (Carpenter); Recent, California.

Shell medium; body whorl large; sutures narrow, deep; varices slightly oblique, some occasionally very large; sometimes coronated just below suture; spiral sculpture of rather prominent ribs, not going onto varices; umbilicus present in type but not necessary; no basal disk or keel. Mostly in shallow water.

Pliocene to Recent.

EPITONIUM (ASPERISCALA) CEDROSENSE Jordan and Hertlein

Epitonium cedrosensis E. K. JORDAN and HERTLEIN, *1926*, California Acad. Sci., Proc., ser. 4, vol. 15, p. 446, pl. 3, fig. 3, (July 22).
Epitonium (*Asperiscala*) *cedrosense* Jordan and Hertlein, GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 857.

The large number of spiral ribs (30) on the body whorl are distinctive.

Occurrence.—Type locality: Berstein's Abalone camp, Cedros Island, Lower California, Mexico; Pliocene.

Pliocene: Cedros Island and Turtle Bay, Lower California, Mexico (Jordan and Hertlein).

Type.—Holotype, C. A. S., no. 2116.

EPITONIUM (ASPERISCALA) DALLASI E. K. Jordan and Hertlein

Epitonium dallasi E. K. JORDAN and HERTLEIN, *1926*, California Acad. Sci., Proc., ser. 4, vol. 15, p. 447, pl. 30, fig. 2, (July 22).
Epitonium (*Asperiscala*) *dallasi* E. K. Jordan and Hertlein, GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 857.

The large number of varices (18 to 20) is distinctive of this species.

Occurrence.—Type locality: 1 mile southeast of Turtle Bay, Lower California, Mexico; Pliocene.

Pliocene: at the type locality.

Type.—Holotype, C. A. S., no. 2122.

EPITONIUM (ASPERISCALA) HEMPHILLI (Dall)

Plate 56, figure 5

Scala hemphilli DALL, *1878*, U. S. Nat. Mus., Proc., vol. 1, p. 16, (reprinted in Smithsonian Misc. Coll., vol. 19, 1880).—COOPER *1888*, California State Mineralogist, 7th Ann. Rept., p. 263.—ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 264.—DE BOURY, *1918*, Jour. Conchology, vol. 64, p. 35.

Epitonium hemphilli DALL, *1917*, U. S. Nat. Mus., Proc., vol. 53, p. 472.

Epitonium (*Boreoscala*) *hemphilli* (Dall), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 856.

Because described at an early date without figures the identity of this species has remained long unknown, even though it is fairly abundant in the San Diego Pliocene.

Shell medium, moderately heavy; umbilicus closed; body whorl fairly large; six or more whorls in adult, nuclear whorls lost in all specimens at hand; whorls nearly semicircular in outline, rather loosely appressed against the preceding whorl, crossed by 10 or 11 strongly reflexed varices varying from thin to heavy, usually with sharp spinose angulation just below suture; on whorls of the spire there are about 14 spiral threads with interspaces of equal size, those on the greatest convexity of the whorl being the most prominent while those just below the suture are obsolete in some specimens, on the body whorl continuing into the closed umbilical area; in some of the interspaces there are fine secondary threads; aperture oval, entire, outer lip thickened by last varix, inner lip rather thin.

Diameter of hypotype, 7.3 mm.; height, 13.7 mm.; whorls, 4.

Remarks.—This species resembles *E. bellastriata* (Carpenter) but is more slender, non-umbilicate, and has only 10 or 11 varices, instead of 15 or more. The specimens from C. A. S., loc. 14072, are labeled "*Scalaria bellastriata* Carpenter, slender form," an old identification by Hemphill. *Epitonium* (*Asperiscala*) *clarki* T. S. Oldroyd also resembles this species closely, but it has 14 to 16 varices which are not always posteriorly reflexed, and the umbilicus is open. The three species are closely related, and it is possible that more material may show a gradation from one to another. All have the same basic number of spiral ribs, but more of them show on the spire of the more loosely coiled forms.

Occurrence.—Type locality: San Diego well, San Diego, Calif.; Pliocene.

Pliocene: fairly abundant in San Diego Pliocene.

Pleistocene: upper San Pedro series of San Pedro, "one immature specimen" (Arnold, 1903).

Types.—Holotype, U. S. Nat. Mus., no. 7991; hypotype, U. C., no. 30148.

Subgenus CRISPOSCALA de Boury, 1886

Crisposcala DE BOURY, *1886*, Mon. Scalidae, p. 1.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 28.

Type: *Epitonium crispum* (Lamarck); Eocene.

Shell fragile, medium size, sutures deep; varices more or less serrated, usually reflexed posteriorly, often spinous just below suture; reflexed surface of the varices covered with a fine network of crossed spiral lines, producing a "decussate" appearance; spiral ribs of various sizes between the varices; small basal disk formed by angulation of the varices; aperture circular, peristome continuous. Living in New Caledonia (de Boury).

Eocene to Recent.

EPITONIUM (CRISPOSCALA) EFFERUM Bramkamp, n. sp.

Plate 56, figure 10

Epitonium (*Dentiscala*) *efferum* BRAMKAMP, n. sp., *MS.*

Bramkamp's description is as follows. Shell medium sized, rather stout, loosely coiled. Axial sculpture of later whorls consisting of 16 to 20 strong, retractive, somewhat recurved axial lamellae which rise to points on shoulders of whorls, coronating the sutures. Anterior and outer faces of axial lamellae sculptured by very fine spiral lines which are crossed by a series of about equally fine

subregular axial lines, which give a finely decussate sculpture. Interspaces between axials sculptured by about 30 fine spiral lines which are not decussate by axial sculpture. Younger whorls showing less marked coronation by the axials at the whorl shoulder, and with weaker, less recurved axials. Basal disk strongly differentiated, about one-half diameter of shell, strongly concave, sculptured by weak continuations of the axials, with suggestion of a broad spiral rib about center of the concavity that results from sharp flexing of axials at this point, sculptured over all by very fine spiral lines. Aperture subcircular, with interoventral expansion of basal lip. Peristome complete.

Length of holotype, 12.7 mm. (apex lacking); diameter, 6.2 mm. (outer lip broken). Length of paratype, 9.3 mm. (nucleus lacking); diameter, 4.6 mm.

The species appears to belong to *Crisposcala* rather than *Dentiscala*. It is especially characterized by the finely decussate sculpture.

Occurrence.—Type locality: Bramkamp loc. 50 B, Imperial formation, San Gorgonio Pass, Calif.

Middle or upper Miocene.

Types.—Holotype, U. C., no. 30158; paratype: U. C., no. 30191.

Subgenus CIRSOTREMA Mörch, 1852

Cirsotrema MÖRCH, *1852*, Cat. Conch. Yoldi, p. 49.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 49.

Type: (monotypic) *Epitonium varicosum* (Lamarck); Recent, Philippines and Oceanica.

Shell thick and massive, sometimes very large; whorls convex, sutures deep; ornamented by thick axial varices, foliaceous or crenulated, more or less reflexed posteriorly, usually not continuous from whorl to whorl, but masking suture completely; primary spirals very coarse, often with finer spirals in interspaces; basal disk bounded by a very prominent posterior "enlargement" of the varices not continuous between any two varices; aperture almost circular; peristome thick and continuous although the inner lip may be somewhat thinner; ornamentation very variable. Living in Philippines and Oceanica.

Eocene to Recent (Cossmann, 1912).

EPITONIUM (CIRSOTREMA) CLALLAMENSE Durham, n. sp.

Plate 56, figures 27, 28

Shell moderately large to large in size; rather heavy; about 9 well-rounded whorls; sutures deep; ornamented by 8 to 10 heavy varices with a prominent angulation just below the suture; interspaces approximately one and one-half times as wide as varices; 3 low, broad spiral ribs on the central portion of the whorl, above these there are 2 or 3 indistinct spirals; the three more prominent spirals can be seen on the outer surface of the varices on well-preserved specimens; character of the aperture indeterminate.

Diameter of holotype, 15.5 mm.; height, 26.8 mm., whorls (incomplete), 3.

Remarks.—The lesser number of much heavier varices distinguishes this species from *Epitonium* (*Cirsotrema*) *saundersi* Tegland.

Occurrence.—Type locality: C. A. S., loc. 210, Clallam Bay, Wash. Also, Tegland loc. T6 (probably in the same vicinity as C. A. S. loc., 210); N. P., loc. 139 Carmanah Point, Vancouver Island, B. C. All probably middle Oligocene.

A single poorly-preserved specimen from U. C., loc. A-368, from the base of the Oligocene as exposed in the quarry at Oakville, Wash., may represent this species. It has about 11 heavy varices.

Types.—Holotype, C. A. S., no. 7003; paratypes, U. C., no. 30170. Identified specimens are in U. W., also L. S. J. U., nos. 6009, 6010.

EPITONIUM (CIRSOTREMA) SAUNDERSI Tegland

Plate 57, figure 21

Epitonium (*Arctoscala*) *saundersi* TEGLAND, *1933*, California Univ., Dept. Geol. Sci., Pub., vol. 23, p. 133, pl. 13, figs. 7–9.

? *Epitonium* sp. WEAVER, *1916*, California Acad. Sci., Proc., ser. 4, vol. 6, p. 51.

The holotype of this species has but 14 varices, the paratype 15, and a topotype (U. C., no. 32225) has only 10 varices. In addition to the three described low broad spirals there are at least three

more that are less prominent on the type—two just below the suture and close together and one just above the suture. There is a slight reflexing of the varices onto the preceding whorl, and on some specimens there is a tendency for a slight angulation to develop on the varices at the top of the whorl.

Diameter of holotype, 11.8 mm.; height, 28.7 mm.; whorls, 4.5.

Diameter of a topotype (U. C., no. 30173), 11.0 mm.; height, 31.0 mm.; whorls, 5.25.

Occurrence.—Type locality: U. C., loc. 681, type Blakeley "Oligocene." Also U. C., loc. A-1806.

Types.—Holotype, U. C., no. 32227; paratype, U. C., no. 32226; hypotypes, U. C., no. 30173, 30174. Identified specimens, L. S. J. U., no. 6011.

Epitonium (Cirsotrema) posoense
Anderson and Martin

Epitonium posoensis Anderson and Martin, *1914*, California Acad. Sci., Proc., ser. 4, vol. 4, no. 3, p. 68, pl. 7, fig. 10.

No specimens other than the type that are referable to this species have been seen. The shoulders of the whorls are much more angulated than shown in the original figures. Edges of the varices are marked by very fine spiral striations; there are four heavy spiral ribs with interspaces equal in size; the "basal keel" is prominent.

Occurrence.—Type locality: originally cited as C. A. S., loc. 65; now catalogued as C. A. S., loc. 2064; Kern River, "Temblor," Miocene.

Type.—Holotype: C. A. S., no. 144.

Epitonium (Cirsotrema) howei
Durham, n. sp.
Plate 56, figure 8

Shell of moderate size, fairly heavy, having about seven whorls (incomplete); whorls well rounded; sutures deep; ornamented by nine prominent varices strongly reflexed posteriorly, bending slightly back as they leave the suture and then straightening out to form slight coronating points just below the suture; interspaces nearly three times as wide as base of varices; on median half of whorl there are about four low, heavy threads twice as broad as their interspaces; areas above and below the four spirals apparently obsolete of spiral ornamentation; between the lowest two spirals there is usually a fine secondary rib, faint expressions of the spiral ribs show on the outer surface of the varices; "basal keel" very prominent; aperture slightly ovate.

Diameter of holotype, 10.8 mm.; height, 21.4 mm.; whorls (incomplete), 4.

Occurrence.—Type locality: Coos Bay Pliocene, C. A. S., loc. 12.

Type.—Holotype, C. A. S., no. 7004.

Epitonium (Cirsotrema) n. sp. *A*, Durham
Plate 56, figure 21

A single fragmentary specimen of an *Epitonium* apparently near *E.* (*Cirsotrema*) *clallamense*, n. sp., is found in the "Temblor" of the Kern River area. It is a large, rather heavy shell, probably with eight or nine well-rounded whorls; sutures very deep; ornamented by six heavy prominent varices with interspaces about one and one-half times their width; spiral ornamentation is indeterminate but it appears to be similar to the above-cited species; "basal keel" prominent.

Diameter of holotype, 15.0 mm.; height, 21.8 mm.; whorls (incomplete), 2.

Occurrence.—C. A. S., loc. 673, near Pyramid Hill, Kern River, Calif.; "Temblor" Miocene.

Type.—These notes are based on specimen C. A. S., no. 7005.

Epitonium (Cirsotrema) n. sp. *B*, Durham

Two specimens of *Epitonium* resembling most closely *E.* (*Cirsotrema*) *clallamense*, n. sp., are at hand. They were found 980 feet below the Kreyenhagen-Temblor contact in sec. 17, T. 16 S., R. 13 E., Fresno County, Calif.; probably of Tejon Eocene age. They have about nine varices and, as nearly as can be determined, about eight spiral ribs. The preservation is such that they

cannot be accurately identified or described. They are in a collection (no. 565) of H. G. Schenck at Stanford.

Subgenus BOREOSCALA Kobelt, 1902

Boreoscala KOBELT, *1902*, Icon. der Schalentragenden Europäischen Meeresconchylien, p. 23.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 54.
Arctoscala DALL, *1908*, Nautilus, vol. 22, p. 80; *1909*, U. S. Geol. Survey, Prof. Paper 59, p. 53.
Catenoscala DALL, *1908*, Nautilus, vol. 22, p. 80; *1909*, U. S. Geol. Survey, Prof. Paper 59, p. 53.
Liroscala DE BOURY, *1909*, Jour. Conchology, p. 254.
Type: (original designation) *Epitonium greenlandicum* (Perry); Recent, boreal.

Shell usually large, heavy; with prominent varices that cross basal keel and continue to aperture; distinct axial sculpture; basal disk present, rather indistinct, bounded by a well-marked keel; aperture oval, outer lip thickened by last varix, inner lip thin; anterior auricle present.

Eocene to Recent. Living in Arctic and Antarctic oceans, south to Japan and southeastern Alaska (Dall, 1917).

Remarks.—Epitonium oregonense Dall, the type of *Catenoscala* Dall, does not differ from typical *Boreoscala* except by the wide band of callus at the sutures and appears to be merely a variant of *Epitonium* (*Boreoscala*) *condoni* Dall.

Dall (1917, p. 472) notes that the number of varices on *E. greenlandicum* (Perry) varies from 8 to 17; that the heaviness of the shell and apical angle varies greatly; and that the spiral ribs in their number, prominence, spacing, and arrangement appear to present the best specific characters in this subgenus.

EPITONIUM (BOREOSCALA) EARLTURNERI
Durham, n. sp.
Plate 56, figure 9

Holotype (incomplete) large, moderately heavy; approximately two well-rounded whorls, including body whorl, remain; sutures rather deep; ornamented by 14 to 16 very prominent, rather close set varices that are strongly reflexed posteriorly so that in a cross-section profile they are hook-shaped; at the suture varices are reflexed against those of preceding whorl; spirally ornamented by about 14 prominent rounded threads slightly narrower than corresponding interspaces; for a slight distance below suture, in addition, there are several very fine spiral threads; in interspaces between the larger spirals there are three secondary spiral threads of much finer size; near base of the well-rounded body whorl there is a moderately heavy spiral marking the slight angulation of the basal disk; aperture broadly elliptical.

Named in honor of Dr. F. E. Turner whose paper on the Eocene of Oregon will appear soon.

Diameter of holotype, 22 mm.; height, 31 mm.; whorls, 2.

Occurrence.—Type locality: U. C., loc. A-715; Coaledo formation of Oregon, equivalent to Tejon of California.

Type.—Holotype, U. C., no. 30154.

EPITONIUM (BOREOSCALA)
INSECURITUM Hanna
Plate 56, figure 19

Epitonium (*Boreoscala*) *washingtonensis* WEAVER and PALMER, *1922*, Washington Univ., Pub. in Geology, vol. 1, no. 3, p. 30, pl. 11, fig. 19.
Epitonium insecuritum HANNA, *1924*, California Acad. Sci., Proc., ser. 4, vol. 13, p. 165, new name for *E.* (*Boreoscala*) *washingtonensis* Weaver and Palmer.
not *Epitonium washingtonensis* WEAVER, *1916*, Washington Univ., Pub. in Geology, vol. 1, no. 1, p. 43, pl. 4, figs. 46, 47.—DICKERSON, *1917*, California Acad. Sci., Proc., ser. 4, vol. 7, p. 160, pl. 31, figs. 7*a*, *b*.

Contrary to the original description there are only eight primary spiral ribs; interspaces are about two and one-half times as wide as spirals; basal keel moderately prominent; below it are numerous fine spiral striae; anterior auricle rather prominent.

Occurrence.—Type locality: U. W., loc. 319, Cowlitz Eocene, Olequah Creek.

Type.—Holotype, U. W.

EPITONIUM (BOREOSCALA) CONDONI Dall
Plate 57, figure 4

Arctoscala condoni DALL, *1908*, Nautilus, vol. 22, p. 80, *nomen nudum.*

Catenoscala oregonensis DALL, *1908*, *loc. cit.*, *nomen nudum.*

Epitonium (*Arctoscala*) *condoni* DALL, *1909*, U. S. Geol. Survey, Prof. Paper 59, p. 53, pl. 3, figs. 1, 12.

Epitonium (*Catenoscala*) *oregonense* DALL, *1909*, U. S. Geol. Survey, Prof. Paper 59, p. 54, pl. 3, fig. 3.

Epitonium condoni Dall, WEAVER, *1916*, Washington Univ., Pub. in Geology, vol. 1, no. 1, p. 30; *1916*, California Acad. Sci., Proc., ser. 4, vol. 6, p. 38.—SCHENCK, *1927*, California Univ., Dept. Geol. Sci., Pub., vol. 16, p. 453; *1928*, *idem.*, vol. 18, pp. 11, 14, 15.

not *Epitonium condoni* Dall, DICKERSON, *1917*, California Acad. Sci., Proc., ser. 4, vol. 7, p. 160, pl. 29, fig. 13.—VAN WINKLE, *1918*, Washington Univ., Pub. in Geology, vol. 1, no. 2, p. 76.—WAGNER and SCHILLING, *1923*, California Univ., Dept. Geol. Sci., Pub., vol. 14, pp. 243, 244, 247, 252.

Epitonium oregonense Dall, SCHENCK, *1928*, California Univ., Dept. Geol. Sci., Pub., vol. 18, pp. 11, 14, 15.

The two widely separated variants of this species were originally described by Dall as distinct and assigned to two different subgenera. After examination of considerable material I believe that they are members of a single highly plastic species for the following reasons: (1) whenever more than one or two specimens are collected from a locality both kinds are present; (2) both have the same number of primary spiral ribs; (3) there are numerous specimens with intermediate characters; (4) each variant with the shape of *oregonense* can be duplicated, if one disregards the callus, in the *condoni;* (5) the amount of callus in the suture varies from less than in the typical *condoni* to more than in typical *oregonense;* and (6) as far as can be determined, the characters vary independently of one another.

The species, as now defined, has the following variations: number of varices on *condoni*, 10 to 15, on *oregonense* 12 to 21; apical angle 16 to 34 degrees, with 24 as average; whorls moderately convex to nearly flat; almost none to over half of each whorl covered by callus deposited in and above the sutures by the varices. On *condoni* (*s.s.*) the spiral ribs are as follows: five prominent primary ribs on the main part of the whorl; above these there are three or four more closely crowded and less prominent primaries below the suture, the lowest of these being occasionally as prominent as the lower five primaries; on well-preserved specimens successively finer secondary and tertiary ribs can be seen. The first five primary spirals usually produce nodes at their intersection with the varices. On typical *oregonense*, the callus of the suture may cover three of the five prominent primaries of the preceding whorl and part of the less prominent primaries of the last whorl. The basal keel is moderately prominent and below it there are 12 to 15 closely spaced spirals. The aperture is ovate and the auricle is moderately prominent.

Diameter of hypotype (U. C., no. 30156), 15.2 mm.; height, 49 mm.; whorls (nuclear missing), 8.

Several subspecies and varieties may be distinguished.

Occurrence.—Type locality: near Eugene, Ore., Eugene formation, middle Oligocene.

N. P. locs. 1, 3, 125, 128, 148; Univ. Ore., loc. 37; U. C., locs. 3607, A-10, A-1603, A-1604, A-1802, A-1815; C. A. S., loc. 239; Holman locs. H 22, H 78; lower and middle (?) Oligocene of Oregon and Washington.

Types.—Holotype (of *condoni*), U. S. Nat. Mus., no. 135122; paratype, U. S. Nat. Mus., no. 107398. Holotype (of *oregonense*), U. S. Nat. Mus., no. 135123; hypotype, U. C., no. 30156.

EPITONIUM (BORESOCALA) CONDONI (Dall) var. EUGENENSE Durham, n. var.
Plate 57, figure 1

Varices 20 to 21; whorls only slightly convex; callus covering about two-fifths of the whorl; spirals apparently nearly obsolete (absent on the type, which is slightly corroded); spire high.

Diameter of holotype, 16.0 mm.; height, 44.5 mm.; whorls (incomplete), 4.3.

Occurrence.—Type locality: Univ. Ore., loc. 37. Also C. A. S., loc. 239. Eugene formation, middle Oligocene.

Type.—Holotype, C. A. S., no. 7006.

EPITONIUM (BOREOSCALA) CONDONI (Dall) var. HADLOCKENSE Durham, n. var.
Plate 57, figure 9

About 16 varices, whorls only slightly convex; callus very heavy, covering over half of the whorl; varices with a slight posterior curve as they leave the suture.

Diameter of holotype, 13.3 mm.; height, 27.4 mm.; whorls (incomplete), 3.5.

Remarks.—This form may be of stratigraphic importance as it is found at a somewhat higher horizon than other Washington varieties of *condoni*, the associated fauna containing a variety of *Molopophorous lincolnensis* Weaver.

Occurrence.—Type locality: U. C., loc. A-1825, Port Hadlock, Wash.; lower middle Oligocene (?).

Type.—Holotype, U. C., no. 30162.

EPITONIUM (BOREOSCALA) CONDONI (Dall) var. OREGONENSE Dall
Plate 57, figure 5

Epitonium (*Catenoscala*) *oregonense* DALL, *1909*, U. S. Geol. Survey, Prof. Paper 59, p. 54, pl. 3, fig. 3.
Epitonium oregonense Dall, SCHENCK, *1928*, California Univ., Dept. Geol. Sci., Pub., vol. 18, pp. 11, 14, 15.

Distinguished by having the callus covering three of the five lower primary spiral ribs, giving the whorls a flat appearance; varices continue straight anteriorly from the band of callus at the suture.

Occurrence.—Type locality: near Eugene, Ore.; Eugene formation, middle Oligocene.

U. C., locs. A-10, A-1604, A-1802, A-1808; N. P. locs. 125, 128, 148; lower Oligocene (Gries Ranch fauna) of Washington.

Types.—Holotype, U. S. Nat. Mus., no. 135123; hypotype, L. S. J. U., no. 5966.

EPITONIUM (BOREOSCALA) CONDONI (Dall) var. QUIMPERENSE Durham, n. var.
Plate 57, figure 2

Resembles the typical form, but varices make a sharp posterior curve upon leaving the suture, straightening out on upper third of whorl and continuing straight anteriorly from there; whorls well rounded; suture rather deep beneath callus which is moderately heavy.

Diameter of holotype, 17.6 mm.; height, 47.5 mm.; whorls (incomplete), 6.5.

Occurrence.—Type locality: U. C., loc. A-1603, Woodmans Wharf, Wash., lower Oligocene (Gries Ranch fauna). Also, U. C. locs. A-10, A-1802, lower Oligocene (Gries Ranch fauna) of Washington.

Type.—Holotype, U. C., no. 30158.

EPITONIUM (BOREOSCALA) CONDONI (Dall) var. TOWNSENDENSE Durham, n. var.
Plate 57, figure 11

Varices very prominent, slightly reflexed posteriorly; spiral ornamentation heavy, producing prominent nodes on varices; basal keel more prominent than on typical form.

Diameter of holotype, 13.3 mm.; height, 32.2 mm.; whorls (incomplete), 5.5.

Occurrence.—Type locality: U. C., loc. A-10, Woodmans Wharf, Wash., lower Oligocene (Gries Ranch fauna). Also U. C., locs. A-1802, A-1824; N. P., loc. 128, lower Oligocene, Gries Ranch fauna.

Type.—Holotype, U. C., no. 30135. Identified specimens, L. S. J. U., no. 6007.

EPITONIUM (BOREOSCALA) CONDONI (Dall) var. WOODMANENSE Durham, n. var.
Plate 57, figure 8

Varices 12 to 14; callus thin or thick, covering about one-third of the whorl; whorls only slightly convex; spire short; angle of spire 34 degrees.

EXPLANATION OF PLATE 57

All figures natural size unless stated otherwise. U. C. indicates California Univ. Mus. Paleontology; C. A. S., California Acad. Sci.; L. S. J. U., Stanford Univ. Paleont. Type Coll.

FIGS. *1*—*Epitonium* (*Boreoscala*) *condoni* Dall var. *eugenense* Durham, n. var. Holotype, C. A. S., 7006, Eugene formation, near Eugene, Ore. (p. 494)

2—*Epitonium* (*Boreoscala*) *condoni* Dall var. *quimperense* Durham, n. var. Holotype, U. C., 30158, associated with a Gries Ranch fauna, Quimper Peninsula, Wash. Shows posterior curvature of varices as they leave the suture. (p. 495)

3—*Epitonium* (*Boreoscala*) *condoni* Dall subsp. *refulleri* Durham, n. subsp. Holotype, L. S. J. U., 498, loc. N. P.1. Keasey formation, lower Oligocene, Oregon. (p. 497)

4—*Epitonium* (*Boreoscala*) *condoni* Dall. Hypotype, U. C., 30156, associated with a Gries Ranch fauna, Quimper Peninsula, Wash. (p. 494)

5—*Epitonium* (*Boreoscala*) *condoni* Dall var. *oregonense* Dall. Hypotype, L. S. J. U., 5966, typical form, associated with a Gries Ranch fauna, Quimper Peninsula, Wash. (p. 495)

6—*Epitonium* (*Boreoscala*) *condoni* Dall subsp. *janerobertsae* Durham, n. subsp. Holotype, U. C., 30160, associated with a Gries Ranch fauna, Quimper Peninsula, Wash. (p. 497)

7—*Opalia* (*Opalia*) *varicostata* var. *granti* Durham, n. var. Holotype, U. C., 30166. San Diego Pliocene, San Diego, Calif. (p. 502)

8—*Epitonium* (*Boreoscala*) *condoni* Dall var. *woodmanense* Durham, n. var. Holotype, U. C., 30157, associated with a Gries Ranch fauna, lower Oligocene, Quimper Peninsula, Wash. Shows characteristic broad angle of spire. (p. 495)

9—*Epitonium* (*Boreoscala*) *condoni* Dall var. *hadlockense* Durham, n. var. Holotype, U. C., 30162, lower Lincoln, Oligocene, Port Hadlock, Wash. Shows characteristic heavy callus. (p. 495)

10—*Epitonium* (*Boreoscala*) *condoni* Dall subsp. *janerobertsae* Durham, n. subsp. Paratype, U. C., 30161, associated with a Gries Ranch fauna, Blyn, Wash. A slender specimen. (p. 497)

11—*Epitonium* (*Boreoscala*) *condoni* Dall var. *townsendense* Durham, n. var. Holotype, U. C., 30135, associated with a Gries Ranch fauna, Quimper Peninsula, Wash. Shows reflexed varices and strong ornamentation. (p. 495)

12, 13—*Acrilla* (*Ferminoscala*) *dickersoni* Durham, n. sp. *12*, Paratype, U. C., 33571; *13*, paratype, U. C., 33570; type Gries Ranch Oligocene of Washington. (p. 508)

14–16—*Epitonium* (*Boreoscala*) *keaseyense* Durham subsp. *schencki* Durham, n. subsp. *14*, Holotype, H. G. Schenck Coll., 326. Keasey formation, lower Oligocene, near Timber, Ore. *15*, Paratype, U. C., 30163, associated with a Keasey fauna, Holcomb, Wash.; a large gerontic individual showing loss of spiral ribs. *16*, Paratype, L. S. J. U., 6016; a specimen with thin varices; Keasey formation, lower Oligocene of Oregon. (p. 498)

17—*Epitonium* (*Boreoscala*) *keaseyense* Durham, n. sp. Holotype, L. S. J. U., 497; Keasey formation, lower Oligocene, Strassel, Ore. (p. 498)

18—*Opalia* (*Rugatiscala*) *cowlitzensis* Durham, n. sp., ×9. Holotype, U. C., 30171; type Cowlitz, Eocene, Washington. (p. 505)

19—*Opalia* (*Nodiscala*) *retiporosa* Carpenter. Hypotype, U. C., 11789; Pliocene?, 4th and Broadway, Los Angeles, Calif. (p. 505)

20—*Acrilla* (*Ferminoscala*) *becki* Durham, n. sp. Holotype, U. C., 30169, associated with a Gries Ranch fauna, Quimper Peninsula, Wash. (p. 507)

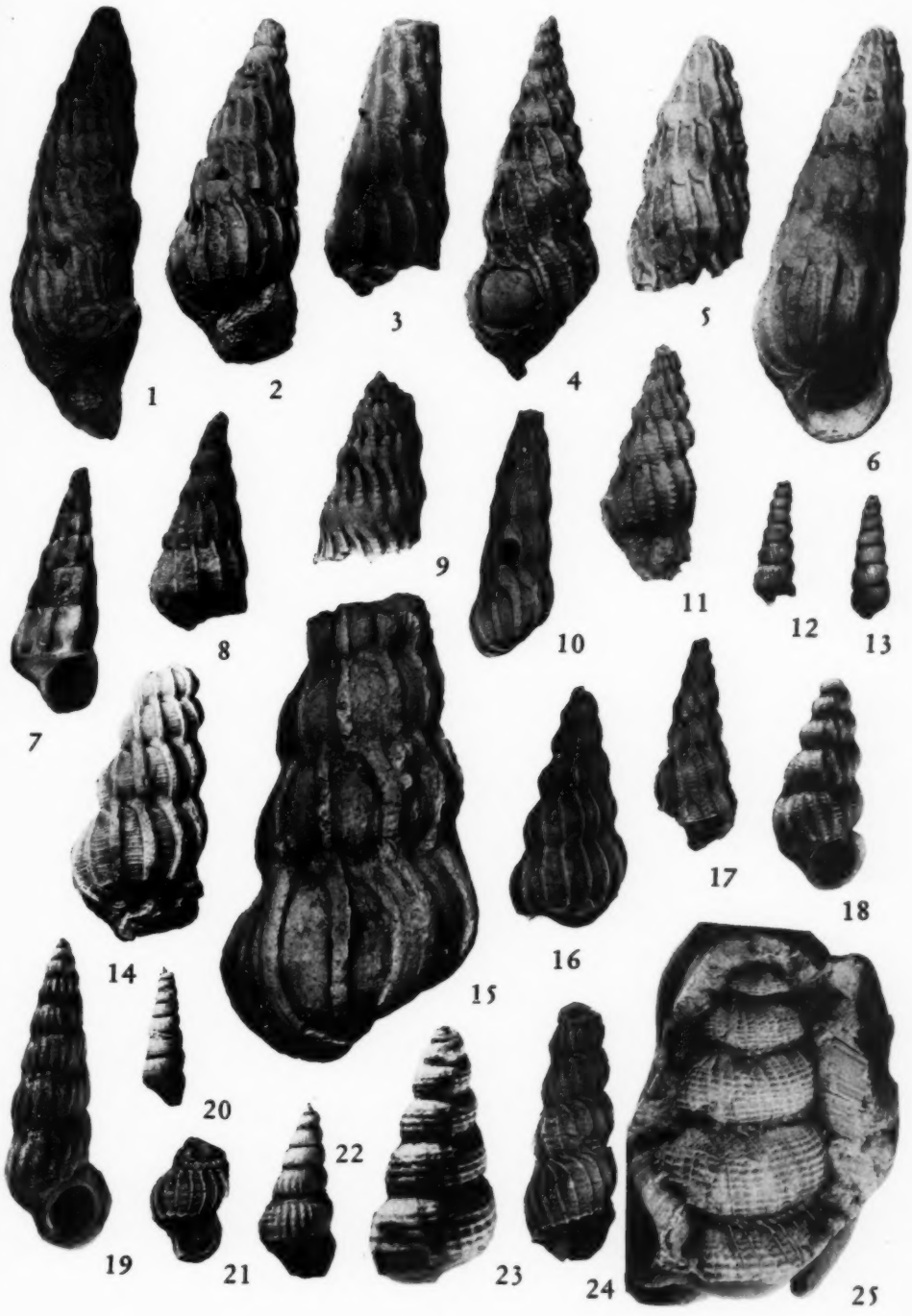
21—*Epitonium* (*Cirsotrema*) *saundersi* Tegland. Hypotype, U. C., 30174, type Blakeley, Oligocene, of Washington. Shows aperture and posterior enlargement of varices making characteristic "basal keel" of *Cirsotrema*. (p. 491)

22—*Acrilla* (*Undiscala?*) *olympicensis* Durham, n. sp. Paratype, U. C., 30186; Twin Rivers, Oligocene, Washington. The surface of the shell has been exfoliated. (p. 510)

23—*Acrilla* (*Ferminoscala*) *berthiaumei* Durham, n. sp., ×6. Holotype, U. C., 30183; type Cowlitz, Eocene, Washington. (p. 507)

24—*Acrilla* (*Ferminoscala?*) *aragoensis* (Turner) Durham n.sp. Holotype, U. C., 33237; Coaledo formation, Eocene, Oregon. (p. 506)

25—*Epitonium atwoodi* Dall. Plasticene squeeze of mold of type. U. S. Nat. Mus., 111072 U. S. Geol. Survey, Sta. 5045, Alaska Peninsula, 4 miles south of Port Moller in Low Pass Canyon. (p. 509)



Durham, Mesozoic and Cenozoic Gastropods

UNIV. OF MICH.

Diameter of holotype, 13 mm.; height, 28.9 mm.; whorls (incomplete), 7.

Occurrence.—Type locality: U. C., loc. A-1802, Woodmans Wharf, Wash., lower Oligocene (Gries Ranch fauna).

Type.—Holotype, U. C., no. 30157.

EPITONIUM (BOREOSCALA) CONDONI (Dall) subsp. JANEROBERTSAE Durham, n. subsp.
Plate 57, figures 6, 10

Shell with six or more only slightly convex whorls, ornamented by 8 to 11 low, broad varices, usually about twice as wide as high but occasionally much wider; sutures possibly moderately deep, but completely filled with callus material deposited by the varices, which covers one-half or more of the preceding whorl, completely filling interspaces; basal keel on body whorl nearly obsolete; above keel are five low, almost obsolete primary spiral ribs, above which are faint indications of less prominent primaries; spiral ribs indiscernible on whorls of spire; aperture ovate.

Diameter of holotype, 20.2 mm.; height, 56.5 mm.; whorls (incomplete), 6.5. Diameter of paratype, 11.4 mm.; height, 34.8 mm.; whorls (incomplete), 6.

Occurrence.—Type locality: U. C., loc. A-1824, Oak Bay, Wash. Also, U. C., loc. A-1811; N. P. 153. All lower Oligocene (Gries Ranch fauna).

Remarks.—This subspecies is obviously rather closely related to *E.* (*Boreoscala*) *condoni* var. *oregonense*, but it occurs associated only with typical *condoni* or alone, and it appears to represent a slightly higher horizon than varieties *oregonense*, *woodmanense*, *quimperense*.

Types.—Holotype, U. C., no. 30160; paratype, U. C., no. 30161. Identified specimens, L. S. J. U., nos. 6013–6015.

EPITONIUM (BOREOSCALA) CONDONI (Dall) subsp. REFULLERI Durham, n. subsp.
Plate 57, figure 3

Distinguished by very straight-sided whorls, shallow sutures, with little callus in sutures; varices not prominent; spiral ribs almost obsolete.

Diameter of holotype, 16.3 mm.; height, 41.1 mm.; whorls (incomplete), 4.

Occurrence.—Type locality: N. P. loc. 1, Keasey Oligocene, Oregon. Also, at junction of forks of the Santiam River, Linn County, Ore., Eugene (?) formation.

Type.—Holotype, L. S. J. U., no. 498.

EPITONIUM (BOREOSCALA) WAGNERI Durham, n. sp.
Plate 56, figure 29

Epitonium condoni Dall, WAGNER and SCHILLING, *1923*, California Univ., Dept. Geol. Sci., Pub., vol. 14, pp. 243, 244, 252.

Shell large, moderately heavy; about eight or nine slightly convex whorls; ornamented by 13 to 14 moderately heavy varices which are reflexed against those of preceding whorl with deposition of a slight amount of callus between them; varices varying in width from as wide as high to twice as wide as high, usually rounded; spirally ornamented by six or seven equidistant rather prominent rounded threads, with interspaces about one and one-half times as wide as the threads; these spirals in passing over the varices produce a moderately prominent node on top of the varix; basal keel not prominent; some evidence of spirals of the same size and spacing below it; aperture ovate.

Diameter of holotype, 14.3 mm.; height, 29.0 mm.; whorls (incomplete), 5.

Remarks.—This species may be distinguished by the six or seven equidistant spirals and the low rounded varices.

A variety of the species occurs at Stanford Survey locs. 903 and 1004 in the San Juan Bautista formation of San Benito County, Calif. It usually shows only six spiral threads with slightly wider interspaces.

Occurrence.—Type locality: U. C., loc. 3174. Also, U. C., locs. 3196, 3193. All San Emigdio formation, lower Oligocene, California.

Type.—Holotype, U. C., no. 30159.

EPITONIUM (BOREOSCALA) KEASEYENSE
Durham, n. sp.

Plate 57, figure 17

Shell large, fairly heavy, about eight or nine moderately-convex whorls, greatest convexity slightly below center; sutures fairly deep; nine fairly heavy axial varices, each reflexed against the corresponding one of preceding whorl and depositing a triangular area of callus in the adjacent sutural area; some varices much wider than others; about 13 primary spiral ribs, of which the first eight are equidistant, with interspaces twice their width, the remaining five become closer together as they approach the suture; spiral ribs pass up posterior side of varices to the top, slightly offset posteriorly as they pass on to top of varices; on better preserved areas of the type, progressively finer secondary and tertiary spirals are discernible; basal keel moderately prominent; below it 12 to 15 closely spaced spiral ribs; aperture ovate.

Diameter of holotype, 12.3 mm.; height, 29.1 mm.; whorls (incomplete), 6.

Remarks.—This species may be distinguished by the 13 primary spirals closely crowded on the top of the whorl and by the 9 to 11 varices. Some variants have thin varices.

Occurrence.—Type locality: N. P., loc. 292; Keasey formation, Oregon. Also, U. C., loc. A-1648, and Holman loc. 36, Keasey formation, Oregon; U. C., loc. 3607, Gries Ranch "Oligocene," Washington.

Type.—Holotype, L. S. J. U., no. 497.

EPITONIUM (BOREOSCALA) KEASEYENSE
Durham subsp. SCHENCKI
Durham, n. subsp.

Plate 57, figures 14, 15, 16

Characterized by wider and heavier varices than in the typical species, without spiral ribs passing on to their top. Also, on later whorls the secondary spiral ribs are usually as prominent as the primaries, thus giving the appearance of many spiral ribs.

Diameter of holotype, 20.2 mm.; height, 38.6 mm.; whorls (incomplete), 4.5.

Occurrence.—Type locality: Holman loc. 35, Washington County, Ore., near cen. sec. 8, T. 3 N., R. 4 W., 1,400 ft. west of tunnel at Tophill on United RR., 2½ miles north of Scofield, Ore.; Keasey formation; colls. J. T. Holman and H. G. Schenck. Also, Holman locs. 26, 36, Keasey Oligocene of Oregon; U. C., locs. A-1816, A-1810, Washington, which are equal in age to the Keasey formation. The specimen from U. C., loc. A-1810 (pl. 57, fig. 16) is extremely large and the spiral ornamentation is obsolete on the later whorls.

Types.—Holotype, H. G. Schenck Coll., no. 326; paratypes, U. C., no. 30163, and L. S. J. U., no. 6016.

EPITONIUM (BOREOSCALA) GREENLANDICUM
(Perry)

Scalaria greenlandica PERRY, *1811*, Conchology, pl. 28, fig. 8.
Scalaria groenlandica Chemnitz, TRYON, *1887*, Man. Conchology, ser. 1, vol. 9, p. 76, pl. 16, fig. 91.
Epitonium (Boreoscala) greenlandicum Perry, DALL, *1917*, U. S. Nat. Mus., Proc., vol. 53, p. 472.—OLDROYD, *1927*, Stanford Univ., Dept. Geol., Pub., vol. 2, pt. 2, p. 55.
Boreoscala greenlandica Perry, DALL, *1919*, Washington Acad. Sci., Jour., vol. 9, p. 2; *1921*, U. S. Nat. Mus., Bull. 112, p. 114.
Epitonium (Boreoscala) greenlandicum (Perry), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 856.

The five broad spiral ribs with narrow interspaces are characteristic of this species.

Occurrence.—Type locality: Greenland, Recent.

Pliocene: upper Pliocene of St. George Island, Pribilof Islands (Dall, 1919).

Pleistocene: Pleistocene terraces of Japan (Dall, 1917).

Recent: Circumboreal, south to northern Japan and Wrangell, Alaska (Dall, 1921).

EPITONIUM (BOREOSCALA) sp., cf.
GREENLANDICUM (Perry) Clark

Epitonium (Boreoscala) cf. *groenlandica* Chemnitz, CLARK, *1932*, Geol. Soc. America, Bull., vol. 43, pp. 824, 845.

Our two specimens of this species are very poorly preserved, but what can be seen of the spiral ribbing is similar to that of typical *greenlandicum;* the varices appear to be a little heavier and are about 15 in number.

Occurrence.—Poul formation, "upper Oligocene," southern Alaska.

Types.—Hypotypes: U. C., no. 32464.

EPITONIUM (BOREOSCALA) COOSENSE Durham, n. sp.

Plate 56, figure 30

Shell large, fairly heavy, having about nine well-rounded whorls; sutures deep; ornamented by nine or ten heavy lamellar varices with interspaces about twice their width; varices curve posteriorly from suture for a short distance and then straighten out; on central portion of body whorl are three rounded nearly equidistant spiral threads with interspaces three to four times their width; on upper third of whorls are about seven closely spaced, rounded spirals tending to become obsolete on later whorls, their interspaces approximately equal in width to the spiral threads; immediately below the three primary spirals are three to four flat spirals with interspaces not as wide as the flat spirals; indistinct secondary spiral threads may be seen between the three primaries; the spirals pass over varices, making small nodes at their intersection; base of body whorl marked by a prominent keel with varices passing over it; aperture probably round.

Diameter of holotype, 18.1 mm.; height, 45.8 mm.; whorls (incomplete), 7.

Occurrence.—Type locality: near Coos Bay, Oregon, C. A. S., loc. 12, Pliocene (?).

Type.—Holotype, C. A. S., no. 7007.

EPITONIUM (BOREOSCALA) n. sp. *A* Durham

A single badly corroded specimen of *Epitonium* (*Boreoscala*) was found at C. A. S., loc. 293, "Trophon zone, Coalinga beds, SW. ¼ sec. 20, T. 10–21 near top of hill," lower Miocene, collected by R. E. Dickerson. The specimen is so badly corroded that a specific description is impossible. It is a large shell having about eight or nine whorls with about 19 varices, resembling *E.* (*Boreoscala*) *condoni* Dall.

Another specimen, possibly referable to this species, was collected by W. P. Woodring from "sandstone, 25 feet more or less, above base of sandstone mapped as Vaqueros on south limb of Devil's Kitchen syncline, just below Eagles Rest, east side San Emigdio Creek." The matrix is so firmly cemented to the specimen (L. S. J. U., no. 5967) that it is impossible to determine it specifically.

Subgenus STHENORYTIS Conrad, 1863

Sthenorytis CONRAD, *1863*, Philadelphia Acad. Nat. Sci., Proc., vol. 14, p. 565.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9. p. 44.

Type: (subsequent designation) *Epitonium expansum* (Conrad), Miocene.

Shell heavy, body whorl very large, spire short; sutures deep; axial varices prominent, continuous from whorl to whorl, usually recurved posteriorly; spiral ribs usually heavy, basal keel present; aperture nearly round, entire, no distinct auricle; umbilicus usually covered. Living in Atlantic and Pacific in warm waters, to 805 fathoms in tropics, usually on sandy bottoms.

Eocene to Recent.

EPITONIUM (STHENORYTIS) STEARNSII (Dall)

Scala (*Sthenorytis*) *stearnsii* DALL, *1892*, Wagner Inst. Sci., Trans., vol. 3, p. 245, pl. 21, fig. 4.

Scala stearnsii Dall, STEARNS, *1898*, U. S. Nat. Mus., Proc., vol. 21, p. 298.

Epitonium (*Sthenorytis*) *stearnsii* (Dall), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 855.

Apparently no other specimens except the type of this species have been found.

Occurrence.—Type locality: Pacific Beach, San Diego, middle Pliocene.

Type.—Holotype, U. S. Nat. Mus., no. 106904.

EPITONIUM (STHENORYTIS) TOROENSE Dall

Epitonium (Sthenorytis) toroense DALL, *1912*, Smithsonian Misc. Coll., vol. 59, p. 6.—GRANT and GALE, *1931*, San Diego Soc. Nat. History. Mem., vol. 1, p. 855.

Sthenorytis toroense (Dall), DALL, *1925*, U. S. Nat. Mus., Proc., vol. 66, art. 17, p. 27, pl. 18, fig. 5.—HANNA and HERTLEIN, *1927*, California Acad. Sci., Proc., ser. 4, vol. 16, p. 148.

Occurrence.—Type locality: Toro Point, Canal Zone, Panama.

Type.—Holotype, U. S. Nat. Mus., no. 214340. Hanna and Hertlein specimen in C. A. S. coll. from loc. 835, Montserrat Island, Gulf of California, Pliocene (?).

EPITONIUM (STHENORYTIS ?) CRESCENTENSE Durham, n. sp.

Plate 56, figures 11, 15

Type incomplete, large, and moderately heavy; paratype smaller, more complete, in a poorer state of preservation; apparently about five rapidly enlarging well-rounded whorls; sutures deep; ornamented by six varices of irregular width, some broad, flat and heavy, others relatively narrow and rounded, having a tendency to be reflexed posteriorly; at suture the varices overlap onto those of preceding whorl or merely onto the preceding whorl; on body whorl of the paratype there is a faint basal keel marked by a spiral rib; no other spiral ornamentation present; aperture apparently nearly circular on the paratype.

Diameter of holotype, 24.5 mm.; height, 27.9 mm.; whorls (incomplete), 2.

Diameter of paratype, 15.3 mm.; height, 25.0 mm.; whorls (incomplete), 4.

Remarks.—This species is apparently very characteristic of the conglomerate mentioned below and, although the specimens are not very complete, the few varices and rapidly enlarging whorls will distinguish it from any others now known.

Occurrence.—Type locality: U. C., loc. A-1813, Port Crescent, Wash., in conglomerate that rests unconformably on the "middle" Eocene; lowermost Oligocene (?).

Types.—Holotype, U. C., no. 30164; paratype: U. C., no. 30165.

EPITONIUM (STHENORYTIS ?) VENTRICOSUM Clark

Epitonium ventricosum CLARK, *1918*, California Univ., Dept. Geol. Sci., Pub., vol. 11, no. 2, p. 164, pl. 23, fig. 14.

The type of this species is a wax cast. Beyond the fact that it is a large, ventricose species with a large body whorl and a basal keel not much is determinable. The mold does not show any evidence of spirals, although the preservation is such that these might not be evident. The varices are rather knife-like and somewhat reflexed, a character not shown in the cast.

The subgenus is not determinable but the large body whorl and low spire suggest *Sthenorytis*.

Occurrence.—Type locality: U. C., loc. 1165, San Ramon formation, California, upper Oligocene (?).

Type.—Holotype, U. C., no. 11240.

Genus OPALIA H. and A. Adams, 1853

Plate 56, figure 2

Opalia H. and A. ADAMS, *1853*, Gen. Rec. Moll., vol. 1, p. 223.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 77.

Opaliinae COSSMANN, *1912, loc. cit.*, vol. 9, pp. 19, 23.

Clathroscalinae COSSMANN, *1912, loc. cit.*

Type: (by subsequent designation) *Opalia australis* (Lamarck), Recent, Australia.

Shell medium to large, moderately heavy, whorls more or less convex; axially ornamented by strong, more or less heavy ribs; spiral ribs may be present; basal disk usually present, but sometimes obsolete; peristome continuous, outer lip thickened by last axial rib.

Thin sections of the genotype species and other species do not show definitely a distinct inner radially fibrous layer, but it is suggested in one section. The growth laminae proceed from inside to outside of the shell in a more or less regular manner, being excessively thickened to form axial ribs. They come to the shell surface at approximately regular

intervals, not only at the axial ribs, but between them. The fibers of the laminae are at all times approximately radial to the inner surface of the shell.

Upper Jurassic to Recent.

Subgenus OPALIA *sensu stricto*

Shell moderate or large; rather heavy; sutures shallow; body whorl with prominent basal disk and keel; only very fine spiral striations present; aperture ovate, anterior auricle present; outer lip thick, inner lip thin. Living in Arctic and Antarctic oceans, ranging into subtropical conditions in 53 fathoms (San Diego, Calif., Dall, 1917).

Lower Oligocene to Recent.

OPALIA (OPALIA) RUGIFERA (Dall)

Epitonium (*Opalia*) *rugiferum* DALL, *1909*, U. S. Geol. Survey, Prof. Paper 59, p. 52, pl. 3, fig. 10.

Two poorly preserved specimens, possibly referable to this species, are at hand; both have 11 varices.

Occurrence.—"Pliocene of Rock Creek, Columbia County, Oregon." This is, in reality, part of the Keasey formation, lower Oligocene. U. C., loc. A-1810 and N. P. loc. 1, both lower Oligocene, with associated Keasey faunas.

Type.—Holotype, U. S. Nat. Mus., no. 135121.

OPALIA (OPALIA) BRAVINDERI
Durham, n. sp.
Plate 56, figure 13

Shell small, rather thin, having eight whorls, with protoconch missing; whorls only slightly convex; sutures shallow; axial ribs 10 or 11, from one-half to two-thirds the width of their interspaces; on larger specimens occasional extra axial ribs are intercalated; the ribs have a rather convex outline from suture to suture, becoming less prominent as they reach the sutures; in earlier whorls the ribs are rather thin and almost knife-like; body whorl with a prominent basal keel; aperture nearly oval.

Diameter of holotype, 3.8 mm.; height, 10.4 mm.; whorls, 8.

Remarks.—This species may be distinguished from *Opalia* (*Opalia*) *varicostata* Stearns by the smaller apical angle, straight-sided whorls, and slightly greater number of varices. Named in honor of Kenneth M. Bravinder who first noted its occurrence at the type locality.

Occurrence.—U. C., loc. A-1803, Blakeley Oligocene, Seattle, Wash. Also, U. C., locs. A-1804, A-1807, type Blakeley Oligocene.

Type.—Holotype, U. C., no. 30167. Identified specimens, U. W.; U. C., no. 30192; L. S. J. U., no. 6012.

OPALIA (OPALIA) WROBLEWSKYI (Mörch)

Scalaria borealis GOULD, *1852*, U. S. Expl. Exped., Rept., vol. 12, p. 207.—TRYON, *1887*, Man. Conchology, ser. 1, vol. 9, p. 76, pl. 16, fig. 89.

not *Scalaria borealis* BECK, *1839*, in Lyell, Rising of Sweden, p. 37, pl. 2, figs. 11, 12.

Scala wroblewskyi MÖRCH, *1876*, Philadelphia Acad. Nat. Sci., Jour., ser. 2, vol. 8, p. 190.

Opalia borealis Gould, COOPER, *1888*, California State Mineralogist, 7th Ann. Rept., p. 255.—KEEP, *1892*, West Coast Shells, p. 49, fig. 30.—ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 266.

Epitonium (*Opalia*) *borealis* Gould, BERRY, *1908*, Nautilus, vol. 22, p. 38.

Epitonium borealis Gould, CLARK, *1915*, California Univ., Dept. Geol. Sci., Pub., vol. 8, p. 422,

Epitonium (*Opalia*) *wroblewskii* Mörch, DALL, *1921*, U. S. Nat. Mus., Bull. 112, p. 113.—T. S. OLDROYD, *1925*, U. S. Nat. Mus., Proc., vol. 65, art. 22, p. 13.—I. S. OLDROYD, *1927*, Stanford Univ., Dept. Geol., Pub., vol. 2, pt. 2, p. 51, pl. 31, fig. 5.

Epitonium (*Opalia*) *wroblewskyi* (Mörch), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 853.

Shell large, high spired with a few low, sometimes very distinct axial ribs; peristome coalescing with the parietal wall.

Occurrence.—Type locality: Vancouver Island, British Columbia, Recent.

Miocene: lower San Pablo formation, U. C., locs. 409, 525.

Pliocene: excavation at 5th and Hope Sts., Los Angeles (Coll. by Charles M. Jay); Bath-house Beach, Santa Barbara, uppermost Pliocene (Berry).

Pleistocene: lower San Pedro fauna of

Nob Hill cut, San Pedro (T. S. Oldroyd); upper San Pedro series of San Pedro (Arnold).

Recent: Forrester Island, Alaska, to San Diego, Calif. (Dall).

Types.—Holotype, British Mus. Nat. Hist.; hypotype, U. C., no. 33497.

OPALIA (OPALIA) WISHKAHENSIS Durham, n. sp.

Plate 56, figure 17

Shell medium, moderately heavy; whorls rather convex in outline; sutures deep for *Opalia;* oldest whorls of spire broken, probably about eight; ornamented by 15 or 16 moderately prominent rounded varices with interspaces of equal width, continuous from whorl to whorl; body whorl with a prominent basal keel which is usually barely visible in sutures of the preceding whorls.

Diameter of holotype, 9.6 mm.; height, 21.3 mm.; whorls (incomplete), 4.

Diameter of paratype, 6.1 mm.; height, 11.1 mm.; whorls (incomplete), 2.

Remarks.—The 15 or 16 varices make this a very distinctive species.

Occurrence.—Type locality: C. A. S., loc. 202, Wishkah River, Washington, in association with *Opalia* (*Opalia*) *varicostata* Stearns; upper Miocene or Pliocene, Montesano formation.

Types.—Holotype, C. A. S., no. 7008; paratype, C. A. S., no. 7009.

OPALIA (OPALIA) VARICOSTATA Stearns

Opalia varicostata STEARNS, *1875*, Philadelphia Acad. Nat. Sci., Proc. for 1875, p. 463, pl. 27, figs. 2–5.—COOPER, *1888*, California State Mineralogist, 7th Ann. Rept., p. 255.—DALL, *1892*, Wagner Inst. Sci., Trans., vol. 3, p. 245.—STEARNS, *1898*, U. S. Nat. Mus., Proc., vol. 21, p. 298.—ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 267; *1907*, U. S. Nat. Mus., Proc., vol. 32, p. 527.—DALL, *1917*, vol. 53, p. 473.—NOMLAND, *1917*, California Univ., Dept. Geol. Sci., Pub., vol. 10, p. 230, pl. 11, fig. 2.

Epitonium (*Opalia*) *varicostatum* (Stearns), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 853, pl. 24, fig. 20.

Type specimen: U. S. Nat. Mus.

Occurrence.—Type locality: Pacific Beach, San Diego, Pliocene.

Upper Miocene (Pliocene?): a single specimen occurs at C. A. S., loc. 202, Wishkah River, Washington, Montesano formation (?).

Pliocene: middle Pliocene of Pacific Beach (Stearns) and of the old San Diego well in Balboa Park (Cooper), San Diego; Temescal Canyon, near Santa Monica (Arnold, 1907), middle Pliocene; upper Etchegoin, Zapata Creek, Fresno County, Calif. (Nomland, 1917).

OPALIA (OPALIA) VARICOSTATA Stearns var. ANOMALA Stearns

Opalia anomala STEARNS, *1875*, Philadelphia Acad. Nat. Sci., Proc. for 1875, p. 464, pl. 27, fig. 1.—COOPER, *1888*, California State Mineralogist, 7th Ann. Rept., p. 255.—DALL, *1892*, Wagner Inst. Sci., Trans., vol. 3, p. 245.—STEARNS, *1898*, U. S. Nat. Mus., Proc., vol. 21, p. 298.—ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 266.—DALL, *1917*, U. S. Nat. Mus., Proc., vol. 53, p. 473.

Scala anomala Stearns, DE BOURY, *1918*, Jour. Conchology, vol. 64, p. 36.

Epitonium (*Opalia*) *varicostatum* (Stearns) var. *anomalum* (Stearns), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 854.

Occurrence.—Type locality: Pacific Beach, San Diego, Pliocene.

Despite de Boury's statement (1918, p. 36) that this variety belongs to the subgenus *Crassiscala*, it can be proved that it grades directly into typical *Opalia* (*Opalia*) *varicostata* Stearns. It is distinguished by the partial or complete absence of axial ribs and a heavy shell.

Type.—Holotype, U. S. Nat. Mus.

OPALIA (OPALIA) VARICOSTATA Stearns var. GRANTI Durham, n. var.

Plate 57, figure 7

Shell rather thin, high spired, about nine whorls; sutures shallow; whorls only slightly convex; ornamented by eight rounded, slightly convex axial ribs parallel to left side of shell instead of right side, as in normal *varicostata;* basal keel well marked; aperture ovate with basal part flattened; outer lip thin.

Diameter of holotype, 12.1 mm.; height, 32.5 mm.; whorls (incomplete), 8.

Occurrence.—Type locality: U. C., loc. 5093, Pacific Beach, Pliocene, California.

Type.—Holotype, U. C., no. 30166. Identified specimens, U. W., and L. S. J. U., no. 6008.

Subgenus CLAVISCALA de Boury, 1909

Claviscala DE BOURY, *1909*, Jour. Conchology, vol. 57, p. 256.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 92.

Type: (monotypic) *Opalia richardi* (Dautz. and de Boury), living in abyssal depths (de Boury, 1917, p. 56).

Shell large, elongate, spire very high; whorls convex; ornamented by curved axial ribs that do not reach suture; basal disk present, limited by a very prominent basal keel which is noticeable in the sutures, sometimes projecting; fine spiral growth lines present on sides of whorl and on the basal disk; aperture elongate.

Neocomian to Recent, most abundant in the Cretaceous.

Remarks.—Despite objections of Cossmann (1912, p. 93) and Stewart (1926, p. 322), it seems possible that the Cretaceous species belong to the same subgenus as the living ones and that, as suggested by de Boury (1917, p. 56), they have merely migrated into abyssal depths since Cretaceous time.

OPALIA (CLAVISCALA) DISPAR (Gabb)
Plate 56, figure 20

Nerinea dispar GABB, *1864*, California Geol. Survey, Paleontology, vol. 1, p. 113, pl. 19, figs. 66, 66*a*.—ANDERSON, *1902*, California Acad. Sci., Proc., ser. 3, vol. 2, p. 41.—STEWART, *1926*, Philadelphia Acad. Nat. Sci., Proc., vol. 78, p. 322.

This species belongs to *Claviscala*, as Stewart suggested. There appear to be about 18 prominent axial ribs that do not continue from suture to suture on the type; also numerous fine spiral striations, which, together with the growth lines, form a minute cancellated pattern; basal keel very prominent.

Remarks.—This species may be distinguished by its high spire, prominent axial ribs, and prominence of basal keel in the suture.

Occurrence.—Type locality: Cretaceous, Horsetown ("Shasta Group"), North Fork of Cottonwood Creek, Shasta County, Calif.

Types.—Holotype, U. C., no. 11944; hypotype, U. C., no. 12242; plastotype, U. C., no. 30172.

OPALIA (CLAVISCALA) n. sp., Durham

Nerinea dispar? Gabb var., WHITEAVES, *1895*, Royal Soc. Canada, Trans., ser. 2, vol. 1, sect. 4, p. 127, pl. 3, fig. 4; *1903*, Canada Geol. Survey, Mesozoic Fossils, vol. 1, pt. 5, p. 363.

?*Sclaria albensis* (?) d'Orbigny, WHITEAVES, *1876*, Canada Geol. Survey, Mesozoic Fossils, vol. 1, pt. 1, p. 50, pl. 9, fig. 5.

The two species listed above, although they may not be conspecific, are certainly distinct from *Opalia* (*Claviscala*) *dispar* (Gabb). Not having seen any specimens referable to either, I hesitate to give a new name to them. Judging from illustrations both apparently lack the pronounced basal keel of Gabb's species and they have fewer axial ribs.

Occurrence.—"*Nerinea dispar*? Gabb var." was found in the Nanaimo group, Cretaceous, of Hornby Island, British Columbia. "*Scalaria albenis* (?) d'Orbigny" came from the Cretaceous of the Queen Charlotte Islands.

Types.—The disposition of the types is not known.

Subgenus CONFUSISCALA de Boury, 1909

Confusiscala DE BOURY, *1909*, Jour. Conchology, vol. 57, p. 256.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 73.

Type: (monotypic) *Opalia dupiniana* (d'Orb.), Albien.

Shell large; whorls convex, sutures moderately deep; axial ribs prominent, varix-like, not passing regularly from whorl to whorl and not extending on to basal disk; fairly prominent spiral ribs crossing axial ribs; basal disk with fine spiral ribs and peripheral keel; aperture nearly circular, inner lip thin; a small anterior auricle present.

Neocomian to Maestrichtian.

OPALIA (CONFUSISCALA) MATHEWSONII (Gabb)

Scalaria (*Opalia*) *mathewsonii* GABB, *1864*, Paleontology California, vol. 1, p. 212, pl. 32, fig. 278; *1869*, vol. 11, p. 223.
?*Scalaria mathewsonii* Gabb, WHITEAVES, *1879*, Canada Geol. Survey, Mesozoic Fossils, vol. 1, pt. 2, p. 129; *1903*, pt. 5, p. 408. —WHITE, *1889*, U. S. Geol. Survey, Bull. 51, p. 45.
Scalaria mathewsonii Gabb, STANTON, *1893*, U. S. Geol. Survey, Bull. 106, p. 142. —TURNER, *1894*, U. S. Geol. Survey, 14th Ann. Rept., pt. 2, p. 460.
?*Epitonium* n. sp. a, PACKARD, *1916*, California Univ., Dept. Geol. Sci., Pub., vol. 9, p. 148.
?*Epitonium* sp., PACKARD, *1922*, California Univ., Dept. Geol. Sci., Pub., vol. 13, p. 428.
Epitonium (*Confusiscala*) *mathewsonii* (Gabb), STEWART, *1926*, Philadelphia Acad. Nat. Sci., Proc., pp. 321, 322, pl. 24, fig. 20.

The species has been figured and reviewed by Stewart. It appears possible that Packard's specimens belong to the same species.

Occurrence.—Holotype, probably Cretaceous near Martinez, Calif.; Packard's specimens are from the Cretaceous of the Santa Ana Mountains, Calif. Whiteaves reported a single specimen from the Productive Coal Measures, Division A, of the Sucia Islands, Wash., but was uncertain of the identification.

Type.—Holotype, in collections of the Philadelphia Acad. of Nat. Sci.

OPALIA (CONFUSISCALA) MATHEWSONII (Gabb)?

Plate 56, figure 23

A single specimen from upper Chico beds on the Haggerdorn Ranch, 4 miles northwest of Montagus, Siskiyou County, Calif., appears to be the same as Gabb's species except that it is much larger, and apparently has nearer 16 axial ribs, whereas Stewart (1926) states that the type has about 12 axial ribs. However, as noted before, the exact number of axial ribs is not a good criterion.

Diameter of hypotype, 16.5 mm.; height, 52.0 mm.; whorls, 9.

Type.—Hypotype, C. A. S., no. 7010.

Subgenus DENTISCALA de Boury, 1886

Dentiscala DE BOURY, *1886*, Étude Sous-Genres Scaliidae, p. 21.—COSSMANN, *1912*, Essais Paleoconch. Comp., vol. 9, p. 89.
Type: (original designation) *Opalia crenata* (Linné), Recent, Mediterranean and Atlantic.

Usually small, moderately heavy shell; suture deep and crenulated, with a sharply angulated shoulder just below it; basal disk distinct, bounded by a well-defined keel; non-umbilicate; suture crenulated by axial ribs, which are usually obscure on remainder of whorl; surface covered by a network of fine punctations visible under a microscope; spiral sculpture distinct but fine and easily eroded; anterior and posterior auricles both present; aperture ovate, outer lip thick, inner lip thin. Living in the warmer parts of the Atlantic and Pacific oceans.

Paleocene to Recent.

OPALIA (DENTISCALA) INSCULPTA Carpenter

Opalia (?*crenatoides*, var.) *insculpta* CARPENTER, *1864*, British Assoc. Adv. Sci., Rept. for 1863, p. 660; *1866*, Annals and Mag. Nat. History, ser. 3, vol. 17, p. 277.
Opalia crenatiodes var. (?) *insculpta* Carpenter, COOPER, *1888*, California State Mineralogist, 7th Ann. Rept., p. 255.
Opalia crenatoides Carpenter var. *insculpta* Carpenter, ARNOLD, *1903*, California Acad. Sci., Mem., vol. 3, p. 267.
Dentiscala insculpta Carpenter, DALL, *1917*, U. S. Nat. Mus., Proc., vol. 53, p. 473.—VAN WINKLE, *1921*, Bull. Am. Paleontology, vol. 8, p. 350, pl. 1, figs. 10, 11.
Epitonium (*Dentiscala*) *insculptum* (Carpenter), GRANT and GALE, *1931*, San Diego Soc. Nat. History., Mem., vol. 1, p. 855.

Occurrence.—Type locality: near Santa Barbara, Pliocene (?) or Pleistocene.

? Upper Pliocene: at the type locality.

Pleistocene: Santa Barbara (Carpenter; Cooper); upper San Pedro series at Deadman Island (Arnold).

Types.—Collection at Cornell University (Van Winkle).

Subgenus NODISCALA de Boury, 1889

Nodiscala DE BOURY, *1889*, Rev. Scal. Mioc. et Plioc. de l'Italie, p. 12.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 84.
Type: *Opalia bicarinata* (Sowerby), Recent.

Shell small, slender, non-umbilicate; axial ribs nodose, ill-defined; occasional varices present representing resting stages, the last one very prominent; spiral ribs present, distinct; on last whorl there are two angulations, the lowest representing the keel bounding basal disk; interspaces between spiral ribs strongly punctate; aperture ovate, outer lip much thickened by terminal varix, inner lip moderately thick. Abundant in warm seas, usually in depths of less than 100 fathoms.

Eocene to Recent.

OPALIA (NODISCALA) RETIPOROSA Carpenter

Plate 57, figure 19

Opalia retiporosa CARPENTER, *1864*, California Acad. Sci., Proc., vol. 3, p. 222; *1864*, British Assoc. Adv. Sci., Rept. for 1863, p. 660.

Epitonium (*Opalia*) *retiporosa* Carpenter, MOODY, *1916*, California Univ., Dept. Geol. Sci., Pub., vol. 10, p. 43.

Nodiscala retiporosa Carpenter, DALL, *1921*, U. S. Nat. Mus., Bull. 112, p. 114.

Epitonium (*Nodiscala*) *retiporosum* Carpenter, I. S. OLDROYD, *1927*, Stanford Univ., Dept. Geology, Pub., vol. 2, pt. 2, p. 54.

Epitonium (*Nodiscala*) *retiporosum* (Carpenter), GRANT and GALE, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 855.

The beaded suture, 14 or 15 axial ribs, and perforate interspaces between the ribs are characteristic.

Occurrence.—Type locality: Catalina Island, Calif., in 40 fathoms.

Pliocene: excavation at 4th St. between Hill and Broadway, Los Angeles, (Moody).

Recent: Catalina Island, Calif., to the Gulf of California, Mexico (Dall, 1921).

Types.—Holotype apparently lost, supposed to be at Univ. California but cannot be found; hypotype, U. C., no. 11780.

Subgenus RUGATISCALA de Boury, 1913

Rugatiscala DE BOURY, *1913*, Jour. Conchology, vol. 61, p. 72.

Funiscala de Boury, (part) COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, pp. 86, 87.

Type: (original designation) *Opalia levesquei* (de Boury), Eocene.

Shell slightly heavy, usually small; spire high; whorls convex, sutures deep; heavy axial ribs, sometimes slightly sinuous; spiral ribs of moderate size crossing axial ribs, interspaces not punctate; basal disk thick with a prominent keel, covered by fine spiral ribs; no umbilicus; aperture ovate, no auricle, outer lip thickened, inner lip thin; occasionally irregular varices are present.

Eocene to Miocene.

OPALIA (RUGATISCALA) COWLITZENSIS Durham, n. sp.

Plate 57, figure 18

Shell minute but moderately heavy; about five well-rounded whorls; protoconch broken; slightly tabulate on top; sutures deep; ornamented by about 15 prominently rounded axial ribs slightly wider than their interspaces and dying out as they reach the suture; last axial rib of body whorl and one opposite it are considerably heavier than the rest, with a tendency for the corresponding ones on each whorl to be heavier; nine rather prominent spiral threads, slightly heavier than their interspaces, most prominent on greatest convexity of whorl, and faint evidence of a tenth one just above keel; body whorl has well-defined basal keel with about five spiral threads below it; aperture entire and nearly elliptical, but lower portion wider than upper; inner lip slightly thinner than outer lip.

Diameter of holotype, 1.3 mm.; height, 3.4 mm.; whorls, 5.

Remarks.—A very distinctive little species, apparently belonging to the same group as *Opalia* (*Rugatiscala*) *williamsoni* (Anderson and Martin).

Occurrence.—Type locality: U. C., loc. A-1546, type Cowlitz Eocene, Washington.

Type.—Holotype, U. C., no. 30171.

OPALIA (RUGATISCALA) WILLIAMSONI (Anderson and Martin)

Epitonium williamsoni ANDERSON and MARTIN, *1914*, California Acad. Sci., Proc., ser. 4, vol. 4, p. 68, pl. 7, figs. 9*a*, *b*.

The moderate size, thickened outer lip

and presence of true axial ribs with nonpunctate interspaces are distinctive of this species.

Occurrence.—Type locality: "Temblor" Miocene, Kern County, Calif., on west bank of a small canyon 1¼ miles northeast of Barker's ranch house.

Types.—Holotype, C. A. S., no. 145; paratype, C. A. S., no. 146.

Genus ACRILLA H. Adams, 1860

Plate 56, figure 3

Acrilla H. ADAMS, *1860*, Zool. Soc. London, Proc., vol. 28, p. 241.
Acrillinae COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, pp. 19, 22.
Type: (original designation) *Acrilla acuminata* (H. and A. Adams), Recent, Philippines and adjacent areas.

Shell turreted, imperforate, many-whorled, whorls longitudinally ribbed, basal portion with a prominent spiral ridge which is slightly visible at the suture. Aperture oval, a little produced in front. Peristome incomplete. Columella reflexed, outer lip simple. (Adams, loc. cit.)

Shell thin, slender, medium size; whorls convex, with axial varices; faint spiral sculpture present; basal disk with spiral ribs; aperture oval to subquadrate; outer lip not thickened, inner lip thin, sometimes presenting only the aspect of a callus.

Thin sections of only one species, *Acrilla* (*Ferminoscala*) *becki*, n. sp., were examined. These show that the shell is composed of three layers—an inner clear layer, a medial darker layer, and a thin outer clear fibrous layer. The structure of the inner layer has not been determined; the middle is finely lamellar, composed of radial fibers with much organic material; the thin outer layer is markedly fibrous radially, is sharply separated from the central layer and under high magnification faint growth lamellae may be seen. The radial ribs are produced by a thickening of the middle layer; the outer layer is fairly constant in thickness. The structure is so markedly different from *Epitonium* and *Opalia* as to indicate much need of study of the soft parts to determine whether it is related to the two genera cited.

Maestrichtian to Recent (Cossmann, 1912).

Subgenus FERMINOSCALA Dall, 1908

Ferminoscala DALL, *1908*, Harvard College, Mus. Comp. Zoology, Bull., vol. 43, p. 315. —COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 58.
Type: (original designation) *Acrilla ferminiana* (Dall), Recent, Gulf Panama to California.

Shell relatively large, turritelloid; axially ornamented by numerous fine thread-like varices; spiral ribs about as prominent as axial varices; basal disk present, axial varices passing over it to the peristome, spiral ribs also present on basal disk; aperture ovate, anterior auricle present. Living in Gulf of Mexico and on Pacific Coast in subtropical conditions.

It appears probable, as Woodring (1928, p. 402) has noted, that many Tertiary species referred to *Acrilla* are better referred to *Ferminoscala*.

Lower Oligocene to Recent.

ACRILLA (FERMINOSCALA?) ARAGOENSIS (Turner), Durham n. sp.

Plate 57, figure 24

Epitonium aragöensis TURNER Ms., n. sp.

Shell large for the genus, heavy, slender; whorls ornamented by about 15 low axial ribs, which bend sharply and become tangent to suture, and numerous fine spiral riblets, which are indistinguishable at suture and increase in strength toward anterior portion.

Occurrence.—Type locality: U. C., loc. A-858, Coaledo formation (=Tejon Eocene), Oregon.

Types.—Holotype, U. C., no. 33237 (loc. A-858); length, 31.0 mm. (incomplete), diameter, 13.6 mm. Paratype, U. C., no. 33238 (loc. A-858); length, 42.4 mm. (incomplete), diameter, 15.5 mm.

The new species has less prominent axial ribs than *E. condoni* Dall, *E. rugiferum* Dall, and "*E. washingtonensis*" Weaver and Palmer. It also has a much narrower angle than the last-mentioned species.

The size is much greater than *E. mathewsonii*, which is presumably Cretaceous.

This species has about seven primary spiral threads with interspaces two to three times their width. Below these primaries, and above the prominent basal keel are about six closely spaced secondary spirals; below the basal keel there are about 20 fine closely set spirals of varying sizes, interspaces of which are not wider than the spirals; on better-preserved parts of the holotype, secondary and tertiary spiral threads may be discerned; varices form a sharp node passing over the prominent basal keel and continue to the aperture.

It is possible that this is not a *Ferminoscala* but belongs in some other subgenus of *Acrilla*.

Acrilla (Ferminoscala) tejonensis (Dickerson)?

Epitonium tejonensis Dickerson, *1916*, California Univ., Dept. Geol. Sci., Pub., vol. 9, pp. 420, 433, 449, 491, pl. 38, fig. 4.—Anderson and Hanna, *1925*, California Acad. Sci., Occasional Paper 11, p. 124.

The holotype is an internal mold showing about 20 varices and five or more fairly prominent spiral ribs; a prominent basal keel with a number of spiral ribs below it. Better-preserved material is needed to describe the species completely.

Occurrence.—Type locality: U. C., loc. 672, Domengine formation, Eocene, north of Oil City, Calif. Two poor wax casts from U. C., loc. 1853, Marysville Buttes, Eocene, can probably be referred to this species. Dickerson reported it from the type Tejon and the north side of Mount Diablo. Well-preserved material from the various localities might show that two or more species have been reported under this name.

Type.—Holotype, U. C., no. 11831.

Acrilla (Ferminoscala) berthiaumei Durham, n. sp.

Plate 57, figure 23

Holotype small, incomplete; paratype large, only one whorl; complete shell probably of 9 or 10 whorls; thin; whorls convex; sutures moderately deep; 20 varices on largest whorl of holotype, about 30 on paratype, which is a body whorl; varices not as prominent as spiral ribs, of which there are five to six prominent primaries, equal in width to their interspaces; faint evidence of two very fine secondaries in interspaces; basal keel moderately prominent, below which are about 9 or 10 spiral ribs, a little wider than their interspaces; aperture ovate, inner lip reduced to a very thin band of callus.

Diameter of holotype, 2.8 mm.; height, 6 mm.; whorls, (incomplete), 5.

Remarks.—This species may be distinguished by its greater apical angle (approximately 27 degrees) and by the five to six prominent primary spiral ribs from its nearest relative, *Acrilla* (*Ferminoscala*) *dickersoni*, n. sp., which has an apical angle of about 16 degrees and six or seven primary spiral ribs.

Occurrence.—Type locality: holotype from U. C., loc. A-1546; paratypes from U. C., loc. A-1543; type Cowlitz, Eocene, of Washington.

Types.—Holotype, U. C., no. 30183. Identified specimens, U. C., no. 30184; and U. W. Coll.

Acrilla (Ferminoscala) becki Durham, n. sp.

Plate 56, figure 26; Plate 57, figure 20

Shell tall, slender, thin; about nine post-nuclear whorls; sutures deep; whorls moderately convex; axial sculpture of 17 to 25 irregularly spaced small, rounded thread-like varices, bending slightly backward as they leave suture and then continuing over whorl approximately parallel to right side of spire; interspaces from two to six times width of varices; spiral sculpture of 10 or 11 primary rounded ribs with interspaces approximately equal in width; the uppermost of these primaries may be nearly obsolete; there is usually a fine secondary in interspaces on center of whorl, sometimes almost as prominent as primaries; basal

keel slightly more prominent than primary spirals; below it are 10 to 12 closely spaced spirals; aperture ovate; inner lip very thin.

Diameter of holotype, 5.7 mm.; height, 18.2 mm.; whorls, 9.

Occurrence.—Type locality: U. C., loc. A-1802, Woodmans Wharf, Wash. Also, U. C., loc. A-1815, and N. P. loc. 148. All lower Oligocene of Washington (Gries Ranch fauna).

Types.—Holotype, U. C., no. 30169; paratype, U. C., no. 30193. Identified specimens, U. W. Coll. and U. C., no. 30193.

ACRILLA (FERMINOSCALA) DICKERSONI
Durham, n. sp.

Plate 57, figures 12, 13

Epitonium washingtonensis Weaver, DICKERSON, *1917*, California Acad. Sci., Proc., ser. 4, vol. 7, p. 160, pl. 31, figs. 7*a*, *b*.

not *Epitonium washingtonensis* WEAVER, *1916*, Washington Univ., Pub. in Geology, vol. 1, no. 1, p. 43, pl. 4, figs. 46, 47.—VAN WINKLE, *1918*, Washington Univ., Pub. in Geology, vol. 1, no. 2, p. 76.

not *Epitonium* (*Boreoscala*) *washingtonensis* WEAVER and PALMER, *1922*, Washington Univ., Pub. in Geology, vol. 1, no. 3, p. 30, pl. 11, fig. 19.

Shell of moderate size, thick, about 10 moderately rounded whorls; sutures fairly deep; tall, rather slender; ornamented by about 30 low, nearly square varices curving slightly posteriorly from suture and then straightening out and passing over whorl nearly parallel to left side of shell; interspaces vary from as wide to twice as wide as varices, of which some are considerably heavier than others; spiral ornamentation of seven low rounded ribs with equal interspaces; a band the width of two of these ribs below the ribs and above the basal keel having no spiral ornamentation; seventh spiral, which is a short distance below the suture, is sometimes rather obscure; basal keel only slightly more prominent than spiral ribs above it, while below it there are about eight or nine spiral ribs with interspaces equal to them; aperture ovate; inner lip thin.

Diameter of paratype, 5.5 mm.; height, 16.2 mm.; whorls, 7 (incomplete).

Occurrence.—Type locality: C. A. S., loc. 181; U. C., loc. 3607; type Gries Ranch, Oligocene, of Washington. Also, U. C., loc. 3190, San Emigdio formation of California.

Types.—Holotype, C. A. S., no. 432; paratypes, U. C., nos. 33570, 33571. Identified specimens in U. W. Coll.

ACRILLA (FERMINOSCALA) LINCOLNENSIS
(Weaver)

Plate 56, figure 24

Mesalia lincolnensis WEAVER, *1916*, Washington Univ., Pub. in Geology, vol. 1, no. 1, p. 45, pl. 5, fig. 85.—VAN WINKLE, *1918*, Washington Univ., Pub. in Geology, vol. 1, no. 2, p. 76.

Epitonium sp. (part) WAGNER and SCHILLING, *1923*, California Univ., Dept. Geol. Sci., Pub., vol. 14, p. 244.

Topotypes of this species show, as the original figure seems to indicate, seven primary revolving ribs on whorls of spire and body whorl, with interspaces three to four times as wide; usually there are secondary spiral ribs between primaries, varying from nearly obsolete to occasionally as heavy as primaries; basal keel moderately well developed, below which are about 10 primary threads with interspaces of nearly equal width; about 65 axial varices, sometimes nearly obscure, less prominent than spirals and having no nodes at their intersections.

Remarks.—A single specimen of an *Acrilla* from N. P. loc. 270, near Skamokawa, Wash., appears to represent a species somewhat intermediate between *A.* (*Ferminoscala*) *lincolnensis* (Weaver) and *A.* (*Ferminoscala*) *becki*, n. sp. It is associated with *Bruclarkia columbiana* (Anderson and Martin) and other species of a fauna probably intermediate between that of the Gries Ranch and the type Lincoln beds. Although nearly complete, the specimen has been badly worn by erosion and details are not sufficiently well preserved to be described.

There is now a nearly complete series of species of *Acrilla*, subgenus *Ferminoscala*, ranging from Cowlitz Eocene to

Lincoln Oligocene. These seem to indicate that it may be possible to zone the lower and middle Oligocene of Washington, recognizing several distinct but closely related faunas.

Occurrence.—Type locality: U. W., loc. 256, type Lincoln "Oligocene." Also, U. W., loc. 230? and U. C., locs. A-9, A-1634; Lincoln formation.

Types.—Holotype, C. A. S., no. 464; hypotypes, U. C., nos. 32430, 33709, 30168.

Acrilla (Ferminoscala) pinolensis (Clark)

Epitonium pinolensis Clark, *1918*, California Univ., Dept. Geol. Sci., Pub., vol. 11, no. 2, p. 164, pl. 20, fig. 16.

The type is a very poorly preserved cast, but, contrary to the original description, there is a well-marked keel on the body whorl, a character which is clearly shown in the mold. About 30 fine, longitudinal ribs on body whorl.

Occurrence.—Type locality: U. C., loc. 3055, Kirker tuff, "middle Oligocene."

Type.—Holotype, U. C., no. 11273.

Acrilla (Ferminoscala) atwoodi (Dall)

Plate 57, figure 25

Epitonium (*Acrilla*) *atwoodi* Dall, *1908*, Nautilus, vol. 22, pp. 80, 81.—Grant and Gale, *1931*, San Diego Soc. Nat. History, Mem., vol. 1, p. 860.

This species has not yet been figured. The dimensions given (diameter at base, 34.0 mm.; height, 60.0 mm.; whorls, 5, apex lost) indicate a large species, perhaps not an *Acrilla*.

Occurrence.—Five miles south of head of Port Moller, in Low Pass Canyon, Alaska Peninsula; "Miocene." It is more likely that this is in reality lower Oligocene.

Type.—Holotype, U. S. Nat. Mus., no. 111.

Acrilla n. sp. *A*, Durham

A crushed specimen of what is apparently an undescribed species of *Acrilla* occurs at C. A. S., loc. 213, middle? Oligocene, of Washington. It is possible that this may be an *Acrilla s.s.* Better preserved material is needed, however, to describe it.

Subgenus Undiscala de Boury, 1909

Undiscala de Boury, *1909*, Jour. Conchology, vol. 57, p. 256.—Cossmann, *1912*, Essais paleoconch. comp., vol. 9, p. 71.

Type: (original designation) *Opalia undosa* (Sowerby), Eocene.

Shell solid, medium size; sutures moderately deep, whorls convex; numerous non-lamellar axial ribs; spiral ribs about as prominent as axial ribs; basal disk marked by closely spaced spiral ribs; bounded by peripheral keel; aperture nearly round; outer lip usually not thickened, not sinuous, inner lip very thin.

Eocene to Oligocene.

Acrilla (Undiscala) lolakensis Durham, n. sp.

Plate 56, figure 22

"*Cerithiopsis alternata*" Gabb, Dickerson, *1914*, California Univ., Dept. Geol. Sci., Pub., vol. 8, p. 96, (from loc. 790).

not *Cerithiopsis alternata* Gabb, *1864*, California Geol. Survey, Paleontology, vol. 1, p. 116, and other authors.

Shell of medium size, thin; about 8 to 10 moderately convex whorls of which only 3 are present; sutures fairly deep; between 20 and 22 prominent axial ribs with interspaces about twice their width, continuing straight from suture to suture; crossed by about eight well defined primary spiral ribs, almost as prominent as the axial ribs, with interspaces three times their width; a secondary spiral rib is usually found just above center of interspace; basal keel prominent, with 12 to 15 closely crowded spiral ribs below it; aperture ovate, inner lip reduced to thin band of callus.

Diameter of holotype, 5.9 mm. (average); height, 13.3 mm.; whorls, 3 (incomplete).

Remarks.—The type, which is the only specimen known, is somewhat crushed, but the specific characters are determinable. It is possibly related to *Acrilla* (*Ferminoscala*) *tejonensis* (Dickerson)?, but it has a higher spire and about eight

spiral ribs, whereas Dickerson's species apparently has about five.

Occurrence.—Type locality: U. C., loc. 790, Martinez Eocene, Lower Lake, Calif.

Type.—Holotype, U. C., no. 30182.

ACRILLA (UNDISCALA) WASHINGTONENSIS (Weaver)

Plate 56, figure 18

Epitonium washingtonensis WEAVER, *1916*, Washington Univ., Pub. in Geology, vol. 1, no. 1, pp. 30, 43, pl. 4, figs. 46, 49.—VAN WINKLE, *1918*, Washington Univ., Pub. in Geology, vol. 1, no. 2, p. 76 (in part).

not *Epitonium washingtonensis* Weaver, DICKERSON, *1917*, California Acad. Sci., Proc., ser. 4, vol. 7, p. 160, pl. 31, figs. 7*a*, *b*.

not *Epitonium* (*Boreoscala*) *washingtonensis* WEAVER and PALMER, *1922*, Washington Univ., Pub. in Geology, vol. 1, no. 3, p. 30, pl. 11, fig. 19.

This species has 20 to 24 fairly prominent rounded axial ribs with interspaces of slightly greater width; eight prominent primary spiral ribs with interspaces twice as wide; spiral ribs heaviest near base of whorl, less prominent near top; secondary spiral ribs found in interspaces, becoming nearly as prominent as primaries near top of whorl; basal keel a little more prominent than lower primary spirals, about 12 closely spaced obscure revolving ribs below it.

Occurrence.—Type locality: U. W., loc. 256. Also, U. C., loc. A-9. Both type Lincoln, Oligocene, of Washington.

Types.—Holotype, C. A. S., no. 557; hypotype, U. C., no. 32431.

ACRILLA (UNDISCALA?) OLYMPICENSIS Durham, n. sp.

Plate 56, figure 16; Plate 57, figure 22

Shell of medium size; originally about eight or nine moderately convex whorls; sutures fairly deep; ornamented by approximately 25 prominent, very distinctive axial ribs, which have appearance of true axial ribs on lower part of whorl but are strongly compressed laterally on upper part so as to simulate varices; on central portion of whorl are three fairly prominent spiral ribs with interspaces slightly greater in width, and below lowest one faint evidence of a fourth spiral rib is occasionally seen just above the prominent basal keel; on upper portion of whorl for a space about equal to that occupied by the three primary spiral ribs, there is no evidence of any spiral ornamentation, and it is in this area that axial ribs become varix-like; axial ribs pass over basal keel to aperture; numerous fine spiral ribs superimposed on axial ribs on basal disk; aperture ovate.

Diameter of internal mold of holotype, 5.6 mm.; height, 11.8 mm.; whorls, 6 (incomplete).

Occurrence.—Type locality: U. C., loc. A.-6, Twin Rivers, Oligocene, of Washington. Also, loc. A-6, both of these equivalent to or slightly younger than the type Blakely "Oligocene."

Types.—Holotype, U. C., no. 30185; paratype, U. C., no. 30186. Identified specimens, U. C., no. 30187, and U. W. Coll.

Genus ACIRSA Mörch, 1857

Plate 56, figure 4

Acirsa MÖRCH, *1857*, Prod. Moll. Grönl.—COSSMANN, *1912*, Essais paleoconch. comp., vol. 9, p. 94.

Acirsinae COSSMANN, *1912*, Essais Paleoconch. Comp., vol. 9, pp. 19, 24.

Type: (subsequent designation) *Acirsa borealis* (Beck) (=*Turritella costulata* Mighels), Recent, boreal.

Shell more or less heavy, small to medium size; axial ribs usually nearly obsolete; spiral ribs present; basal disk present; aperture entire although inner lip is often very thin; outer lip sharpened.

The genotype is boreal in distribution but other species range into subtropical conditions.

Bathonien to Recent.

Subgenus ACIRSA s.s.

Shell heavy, moderately slender; fine spiral striae, axial ribs nearly obsolete; basal disk indistinct but with a distinct peripheral groove; umbilicus closed, outer lip sharpened. Boreal or deep water.

Oligocene to Recent (de Boury).

ACIRSA (ACIRSA) VAQUEROSENSIS
Durham, n. sp.

Plate 56, figure 12

Shell of medium size, tall, heavy; whorls slightly convex; sutures shallow; whorls about 10 (nuclear whorls missing); ornamented by about 24 low, irregular, usually inconspicuous axial ribs with interspaces of about the same width; in younger whorls occasional ribs, approximately 180 degrees apart, are rather heavy, probably representing a resting stage during growth; between axial ribs fine incremental lines, variously spaced; spiral ornamentation of about 24 spiral threads of varying prominence and interspaces; just above basal keel of body whorl are four approximately equal spirals with interspaces not quite as wide; in addition there are four more primary spirals, of which the lowest is about one and one-half times as wide as the preceding primary spiral and has a fine secondary spiral thread in the interspace, the last of these four being about equal in prominence to the last of the preceding four; interspaces between first three of the last four primary spirals about as wide as the spirals, but twice as wide between the last two; a fine secondary occurs in each interspace between these primary spirals; about 12 more or less prominent primaries above those already described, with interspaces of approximately equal width, with very faint traces of fine secondaries in their interspaces; above the last 12 and just below suture are about four fine, hardly discernible spirals; a moderately prominent basal keel on part of body whorl, with about 20 fine spirals of varying widths below it, interspaces not as wide as spirals; aperture markedly ovate; outer lip sharp.

Diameter of holotype, 7.9 mm.; height, 20.9 mm.; whorls, 9 (incomplete).

Remarks.—This tall slender heavy shell, with sharp outer lip, is very distinctive among known species of Epitoniidae of the Pacific Coast.

Occurrence.—Type locality: C. A. S., loc. 126, San Luis County, Calif., Vaqueros "Miocene."

Type.—Holotype, C. A. S., no. 7011.

SPECIES OF DOUBTFUL STATUS

"SCALARIA" ALBENSIS d'Orbigny?, Anderson

Scalaria albensis d'Orbigny?, ANDERSON, *1902*, California Acad Sci., Proc., ser. 3, vol. 2, p. 41.

This species is listed in Anderson's check list of the Horsetown beds of the upper Sacramento Valley. It is probable that the specimen on which the identification was made, was destroyed in the San Francisco fire. If correctly identified, it belongs to *Acirsa*, subgenus *Proscala* Cossmann, of which d'Orbigny's species is the type.

"EPITONIUM" sp. indet., Clark

Epitonium sp. indet. CLARK, *1918*, California Univ., Dept. Geol. Sci., Pub., vol. 11, no. 2, p. 164, pl. 21, fig. 8.

This is a cast of a very poorly preserved *Epitonium* or *Acrilla*. Better material is needed to determine anything more definite.

Occurrence.—U. C., loc. 3055, Kirker tuff, middle Oligocene.

Type.—Holotype, U. C., no. 11288.

SPECIES INCORRECTLY REFERRED TO THE EPITONIIDAE

"CIRSOTREMA" TENUISCULPTUM Whiteaves

Cirsotrema tenuisculptum WHITEAVES, *1879*, Canada Geol. Survey, Mesozoic Fossils, vol. 1, pt. 2, p. 127, pl. 16, figs. 3, 3*a–c*; *1903*, pt. 5, p. 408.—MCLELLAN, *1927*, Washington Univ., Pub. in Geology, vol. 2, p. 133.—ANDERSON and HANNA, *1935*, California Acad. Sci., Proc., ser. 4, vol. 23, p. 7.

This species seems to belong in *Mathilda*, subgenus *Acrocoelum* Cossmann, which is included in a separate family, Mathildidae, by most modern paleontologists. It is probable that Anderson and Hanna's specimens represent a new species, as there are considerable differences between them and Whiteaves' original figure.

Occurrence.—"Division A" of the Cretaceous of the Sucia Islands (Whiteaves), Cretaceous (Chico) of Todos Santos

Bay, Lower California (Anderson and Hanna).

"EPITONIUM" MERRIAMI Dickerson

Epitonium merriami DICKERSON, *1917*, California Acad. Sci., Proc., ser. 4, vol. 7, p. 175, pl. 30, figs. 7a, *b*.

This is not an *Epitonium* but appears to be a *Bittium*.

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J. WYATT DURHAM, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA. MANUSCRIPT RECEIVED BY THE EDITOR, SEPTEMBER 10, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 6, PP. 513–516, PLS. 58, 59, SEPTEMBER, 1937

EOCENE SPECIES OF THE GENERA *BULIMINA* AND *BULIMINELLA* FROM CUBA

F. L. PARKER AND P. J. BERMUDEZ

ABSTRACT

Ten species of *Bulimina* and two of *Buliminella* from the Eocene of Cuba are described and figured. These include five new species and two new varieties.

In studying the Eocene faunas of Cuba it was found that the genera *Bulimina* and *Buliminella* were present in abundance. It is believed that the species here recorded will prove of value in the working out of the stratigraphy of the region. This aspect of the problem will be presented in a later paper when the faunas have been more completely studied.

Acknowledgments.—Thanks are due the Grants-in-Aid Committee of the National Research Council for financing the making of the drawings, and to Dr. Joseph A. Cushman for putting the facilities of his laboratory at our disposal and giving many valuable suggestions. The drawings were made by Ann Shepard.

SYSTEMATIC DESCRIPTIONS

Genus BULIMINA d'Orbigny, 1826

BULIMINA TUXPAMENSIS Cole

Plate 58, figures 1*a–c*

Bulimina tuxpamensis COLE, *1928*, Bull. Am. Paleontology, vol. 14, no. 53, p. 212 (12), pl. 1, fig. 23.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 20.

Our specimens closely resemble Cole's species, although there is often a slight roughening of the wall of the lower part of the test which Cole does not mention. It is interesting to note the close relationship of this species to *Bulimina incisa* Cushman from the Cretaceous of Mexico.

The figured specimen is from 4.5 kilometers west of Guanajay on the road to Mariel, Pinar del Rio Province, Cuba.

BULIMINA JARVISI Cushman and Parker

Plate 58, figures 2*a–c*

Bulimina jarvisi CUSHMAN and PARKER, *1936*, Cushman Lab. Foram. Research, Contr., vol. 12, p. 39, pl. 7, figs. 1*a–c*.

Only one specimen referable to this species was found. It occurs at Alturas de Almendares quarry, Havana, Cuba, and is here figured.

BULIMINA SEMICOSTATA Nuttall

Plate 58, figures 3*a–c*

Bulimina semicostata NUTTALL, *1930*, Jour. Paleontology, vol. 4, pp. 274, 285, pl. 23, figs. 15, 16.—CHURCH, *1931*, California State Mineralogist, Rept., pl. B, figs. 4–6.

Our specimens appear to be identical with Nuttall's species from the Guayabal formation of Mexico.

The figured specimen is from El Husillo, Puentes Grandes, Havana, Cuba.

BULIMINA SEMICOSTATA Nuttall var. CRASSICOSTA Parker and Bermudez, n. var.

Plate 58, figures 4*a–c*

Variety differs from the typical form in its larger size and the presence of fewer and heavier costae. Length 0.44 to 0.80 mm.; diameter 0.24 to 0.38 mm.

Remarks.—We have numerous specimens in a poor state of preservation. Further study of better specimens may reveal this form to be a separate species, but its basic resemblance to *Bulimina semicostata* Nuttall seems to point to a varietal difference only.

Type.—Holotype of variety (Cushman Coll., no. 23334) from Alturas de Almendares quarry, Havana, Cuba.

BULIMINA ALAZANENSIS Cushman
Plate 58, figures 5*a–c*

Bulimina alazanensis CUSHMAN, *1927*, Jour. Paleontology, vol. 1, p. 161, pl. 25, fig. 4.

Our specimens closely resemble Cushman's species although they are slightly larger.

The figured specimen is from the upper beds, Cantera Tejar "Consuelo" Cerro, Havana, Cuba.

BULIMINA TARDA Parker and Bermudez, n. sp.
Plate 58, figures 6*a–c*

Test small, tapering, the last-formed whorl forming a third or more of the test; chambers few, four to five whorls, those of the last whorl inflated; sutures fairly distinct, very slightly depressed, showing as dark lines with occasional small, incised areas; wall smooth, coarsely perforate; aperture loop-shaped with a slight lip. Length 0.30 to 0.35 mm.; diameter 0.21 to 0.23 mm.

Remarks.—This form somewhat resembles *Bulimina tuxpamensis* Cole but is much smaller, more rapidly tapering, and has a smoother wall. The two have enough in common, however, to indicate that this species may be the ancestral form.

Type.—Holotype (Cushman Coll., no. 23337) from Loma Principe, cut between F and Avenida de los Presidentes Streets, 20 meters west of José M. Gómez monument, Havana, Cuba.

BULIMINA IMPENDENS Parker and Bermudez, n. sp.
Plate 58, figures 7*a–c*, 8*a–c*

Test small, about one and one-third times as long as broad, very slightly tapering; chambers few, three to four whorls, distinct in last whorl only, those of each whorl overhanging those previously formed to give a distinct collared effect; sutures distinct in last whorl, slightly depressed, previous ones obscured by surface ornamentation; wall spinose or fluted at the lower edge of the last two whorls, the remainder of the test completely covered by short irregular spines; aperture loop-shaped with a slight lip. Length 0.20 to 0.45 mm.; diameter 0.20 to 0.35 mm.

Remarks.—This species differs from *Bulimina curtissima* Cushman and Siegfus in being very much more spinose, in having more chambers, and in the very marked overhang of the chambers.

Type.—Holotype (Cushman Coll., no. 23335) from Alturas de Almendares quarry, Havana, Cuba.

BULIMINA PALMERAE Parker and Bermudez, n. sp.
Plate 59, figures 1*a–c*

Test medium, one and one-half times as long as broad, tapering, with a well-developed, blunt, basal spine; chambers distinct, four to six whorls, last-formed

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EXPLANATION OF PLATE 58

FIGS. *1*—*Bulimina tuxpamensis* Cole, ×53. *a*, Front view; *b*, back view; *c*, apertural view. (p. 513)

2—*Bulimina jarvisi* Cushman and Parker, ×47. *a*, Front view; *b*, back view; *c*, apertural view. (p. 513)

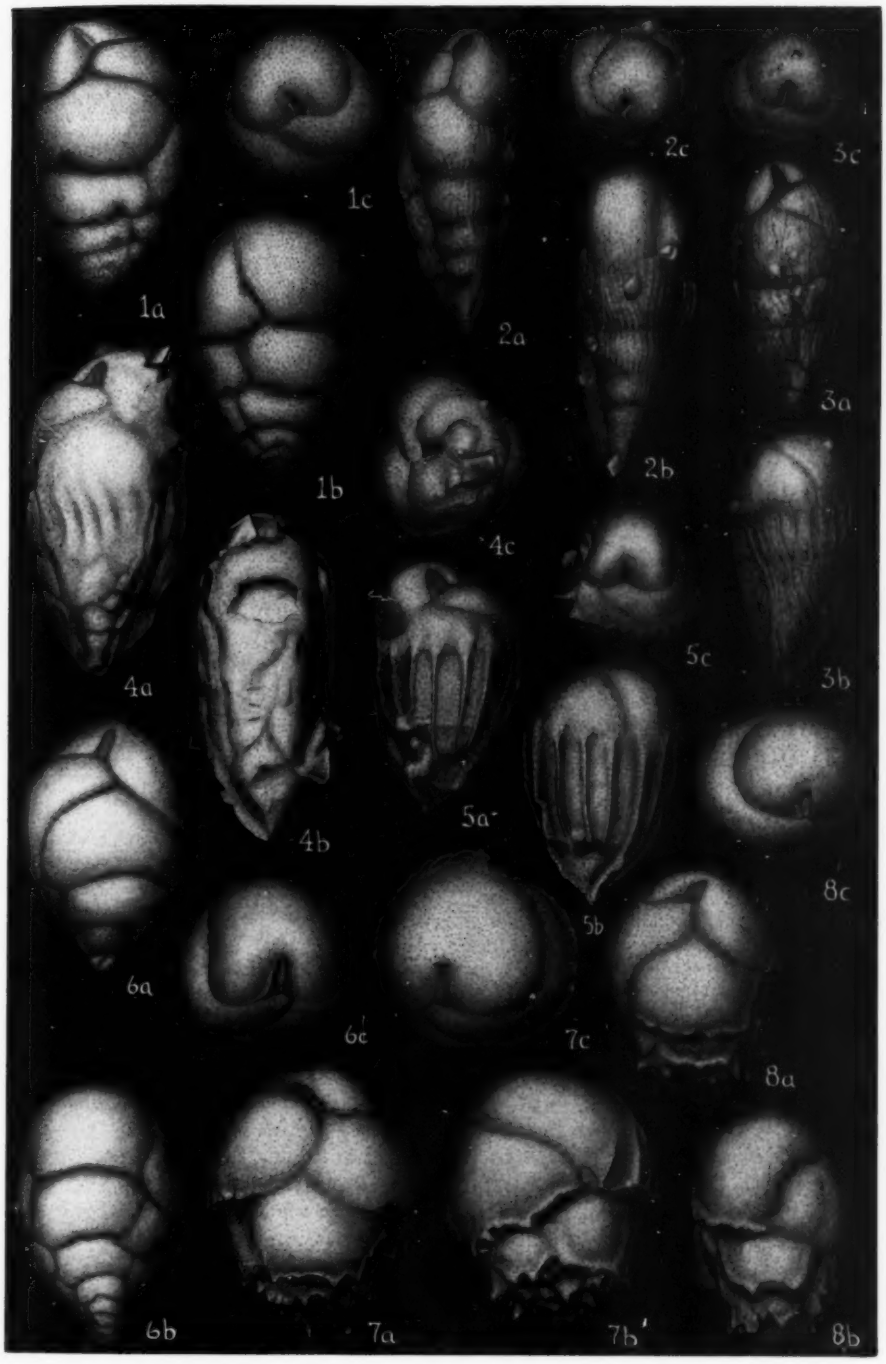
3—*Bulimina semicostata* Nuttall, ×60. *a*, Front view; *b*, back view; *c*, apertural view. (p. 513)

4—*Bulimina semicostata* Nuttall var. *crassicosta* Parker and Bermudez, n. var., ×60. *a*, Front view; *b*, back view, *c*, apertural view. (p. 513)

5—*Bulimina alazanensis* Cushman, ×80. *a*, Front view; *b*, back view; *c*, apertural view. (p. 514)

6—*Bulimina tarda* Parker and Bermudez, n. sp., ×96. *a*, Front view; *b*, back view, *c*, apertural view. (p. 514)

7, 8—*Bulimina impendens* Parker and Bermudez, n. sp., ×80. Fig. *7*, Paratype. Fig. *8*, Holotype. *aa*, Front views; *bb*, back views; *cc*, apertural views. (p. 514)



Parker and Bermudez, Eocene Foraminifera

UNIV. OF MICH.

chambers somewhat inflated; sutures distinct, depressed, incised; wall with blunt spines at the edges of the chambers, the base of the larger spines extending up onto the chambers, remainder of wall smooth, perforate; aperture loop-shaped with a well-defined lip. Length 0.48 to 0.80 mm.; diameter 0.32 to 0.56 mm.

Remarks.—This species differs from *Bulimina arkadelphiana* Cushman and Parker, var. *midwayensis* Cushman and Parker in being much larger, having much coarser spines and fewer of them. It differs from *Bulimina stalacta* Cushman and Parker in its more spinose character, lack of costae, and the slight overhang of the chambers.

The form is named for Mrs. Dorothy K. Palmer of Havana, Cuba.

Type.—Holotype (Cushman Coll., no. 23339) from 1 kilometer north of Arroyo Arenas on road to Jaimanitas (water well), Havana Province, Cuba.

BULIMINA CONSANGUINEA Parker and Bermudez, n. sp.

Plate 59, figures 2*a–c*

Test large, about one and one-third times as long as broad, tapering evenly, usually with a short, blunt, basal spine; chambers distinct in last-formed whorl only, although frequently distinguishable in portions of the remainder of the test, four to six whorls; sutures distinct in last whorl only, very slightly depressed; wall smooth, perforate in the upper part of the last whorl, the remainder ornamented by longitudinal plate-like costae with jagged edges, six to eight visible from the front of the test; aperture loop-shaped with a lip. Length 0.80 to 1.08 mm.; diameter 0.50 to 0.76 mm.

Remarks.—This species differs from *Bulimina jacksonensis* Cushman in its larger size, more numerous and more jagged costae, and the presence of the broad basal spine.

Type.—Holotype (Cushman Coll., no. 23338) from north side of Elvador in Noroña, north of Guanajay, on R Road, Pinar del Rio Province, Cuba.

BULIMINA cf. PUPOIDES d'Orbigny

Plate 59, figures 3*a–c*, 4*a–c*, 5*a–c*

Bulimina pupoides D'ORBIGNY, *1846*, Foram. fossiles vienne, p. 185, pl. 11, figs. 11, 12.—NUTTALL, *1930*, Jour. Paleontology, vol. 4, p. 285; *1935*, Jour. Paleontology, vol. 9, no. 2, p. 127, pl. 14, fig. 22.

Our specimens are very close to d'Orbigny's species, although they are larger and have a thicker wall. The species is a very variable one, but the relative shapes of the chambers and the position and character of the aperture remain the same. It is interesting to note the close relationship between one variation of this species (pl. 59, figs. 3*a–c*) and *Bulimina guayabalensis* Cole var. *ampla* Cushman and Parker from the Eocene of California, a form showing very little variation.

Only references to the occurrence of this species in the Eocene of North and South America have been given in the synonymy. Further study may show that Eocene forms which have been called *Bulimina ovata* d'Orbigny should also be included in this group.

The figured specimens are from the locality under Library of Havana University, Havana, Cuba.

Genus BULIMINELLA Cushman, 1911

BULIMINELLA GRATA Parker and Bermudez, n. sp.

Plate 59, figures 6*a–c*

Test medium, slightly longer than broad, tapering rapidly; chambers four to a whorl, two to three whorls; sutures distinct, broad, flush with the surface, usually incised giving scalloped effect (especially noticeable when wet); wall smooth, finely perforate; aperture rounded with small narrow radial depressions extending from it. Length 0.24 to 0.46 mm.; diameter 0.18 to 0.38 mm.

Remarks.—This form differs from *Buliminella colonensis* Cushman in the shape of the chambers and aperture and the incised character of the sutures.

Type.—Holotype (Cushman Coll., 23340) from Loma Principe, cut between

F and Avenida de los Presidentes Streets, 20 meters west of José M. Gómez monument, Havana, Cuba.

BULIMINA GRATA Parker and Bermudez var. SPINOSA Parker and Bermudez, n. var.
Plate 59, figures 7*a–c*

Variety differs from the typical form in its larger size and in the presence of short, thick, blunt spines in the lower part of the test. In the young forms these blunt spines often cover most of the test. Length 0.48 to 0.78 mm.; diameter 0.40 to 0.66 mm.

Type.—Holotype of variety (Cushman Coll., no. 23341) from north side of Elevador in Noroña, north of Guanajay, on R Road, Pinar del Rio Province, Cuba.

FRANCES L. PARKER, 141 CARLTON STREET, BROOKLINE, MASS. PEDRO J. BERMUDEZ, UNIVERSITY OF HAVANA, HAVANA, CUBA. MANUSCRIPT RECEIVED BY THE EDITOR, JANUARY 7. 1937.

EXPLANATION OF PLATE 59

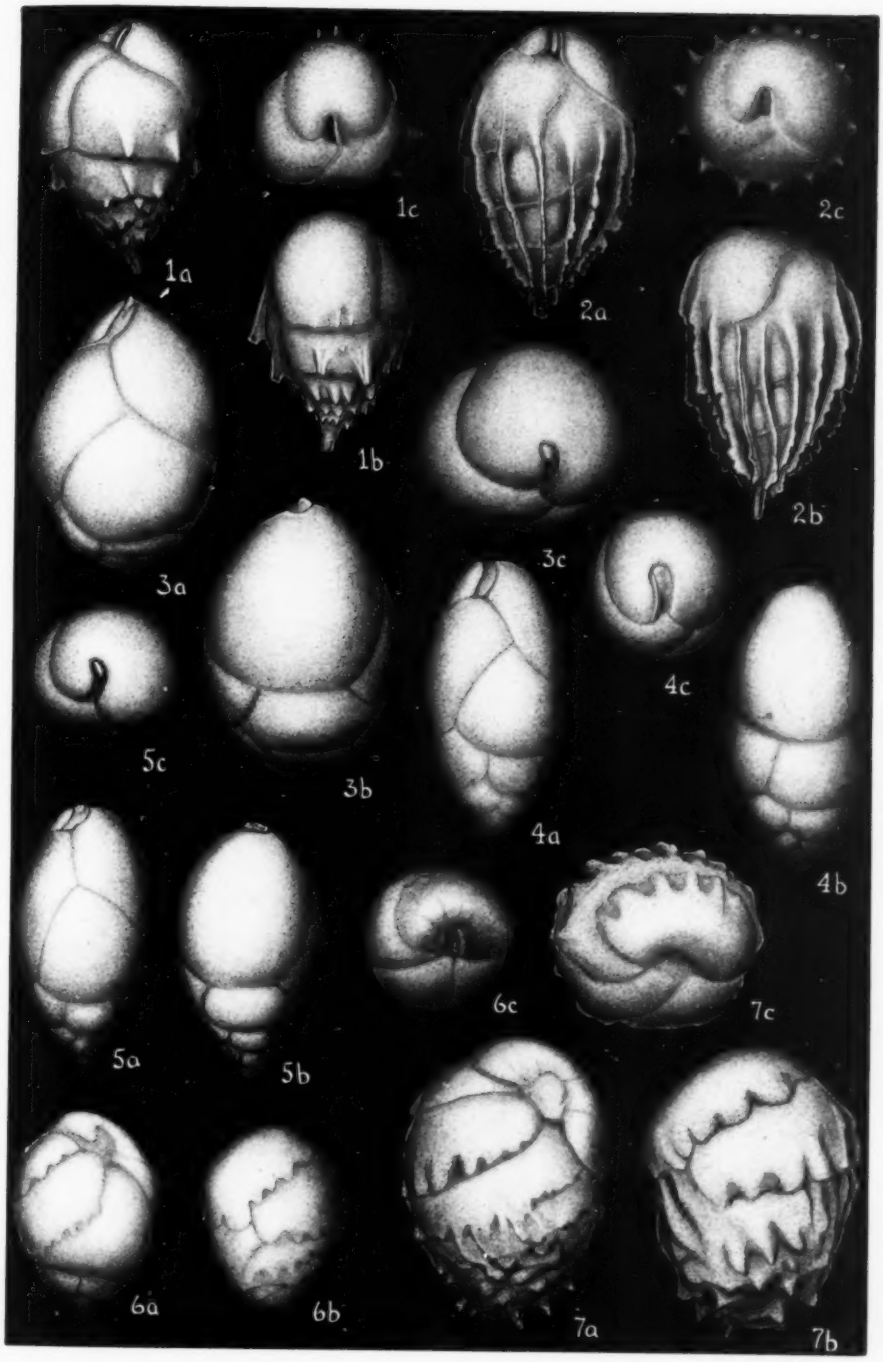
FIGS. 1—*Bulimina palmerae* Parker and Bermudez, n. sp., ×60. *a*, Front view, *b*, back view, *c*, apertural view. (p. 514)

2—*Bulimina consanguinea* Parker and Bermudez, n. sp., ×47. *a*, Front view; *b*, back view; *c*, apertural view. (p. 515)

3–5—*Bulimina* cf. *pupoides* d'Orbigny, ×47. *aaa*, Front views; *bbb*, back views; *ccc*, apertural views. (p. 515)

6—*Buliminella grata* Parker and Bermudez, n. sp., ×60. *a*, Front view; *b*, back view; *c*, apertural view. (p. 515)

7—*Buliminella grata* Parker and Bermudez, var. *spinosa* Parker and Bermudez, n. var. ×54. *a*. Front view; *b*, back view; *c*, apertural view. (p. 516)



Parker and Bermudez, Eocene Foraminifera

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 6, PP. 517–529, PLS. 60–65, SEPTEMBER, 1937

THE *LEPIDOCYCLINA TEXANA* HORIZON IN THE *HETEROSTEGINA* ZONE, UPPER OLIGOCENE, OF TEXAS AND LOUISIANA

DONALD W. GRAVELL AND MARCUS A. HANNA

ABSTRACT

The larger Foraminifera of a horizon in the *Heterostegina* zone of Texas and Louisiana are described and figured. This horizon is named the *Lepidocyclina texana* horizon after *L.* (*Lepidocyclina*) *texana* Gravell and Hanna, n. sp., a rayed and easily recognizable fossil. Associated with *L. texana* are *Operculinoides ellisorae* Gravell and Hanna, n. sp., *Operculinoides howei* Gravell and Hanna, n. sp., *Heterostegina israelskyi* Gravell and Hanna, n. sp., *Heterostegina texana* Gravell and Hanna, n. sp., *Lepidocyclina* (*Lepidocyclina*) *colei* Gravell and Hanna, n. sp. The geographic distribution and stratigraphic position of the *L.* (*Lepidocyclina*) *texana* horizon is discussed.

The object of this paper is twofold, to record the uppermost known *Lepidocyclina* in the Gulf Coast, and to establish a new fossil horizon for subsurface interpretation and stratigraphic correlation, namely the *Lepidocyclina texana* horizon. The larger foraminifera of this horizon are *Operculinoides ellisorae* Gravell and Hanna, n. sp., *Operculinoides howei* Gravell and Hanna, n. sp., *Heterostegina israelskyi* Gravell and Hanna, n. sp., *Heterostegina texana* Gravell and Hanna, n. sp., *Lepidocyclina* (*Lepidocyclina*) *colei* Gravell and Hanna, n. sp., and *Lepidocyclina* (*Lepidocyclina*) *texana* Gravell and Hanna, n. sp. These fossils have given a better understanding of the section in the immediate area as well as the general area bordering the Gulf of Mexico. The problem of correlation with Europe is left open, although certain data are cited which are believed to be pertinent to its solution.

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LOCATION OF TYPE LOCALITY

The fossils described in this paper were secured from cores from the Sun Oil Company's No. 1-A Hamilton, located 1,400 feet south and 1,400 feet east of northwest corner of the H. T. and B. Sec. no. 128, or the J. T. White Survey, Abstract A.-460, Chambers County, Texas. The well was located approximately 13 miles southeast of the town of Anahuac, county seat of Chambers County, It was spudded October 25, 1934, and abandoned as a dry hole at 9,055 feet, March 25, 1935.

In so far as possible, we do not favor the description of new species of fossils from well samples. The ones described here, however, are considered an exception, since the beds containing them have not been found at the surface. In addition, excellent cores were taken in this well, and portions of them were widely distributed among the paleontologists of the Gulf Coast. This allows for extensive examination of material from the type locality.

Heterostegina ZONE

Applin, Ellisor, and Kniker (1925, pp. 100–111) defined and described the *Heterostegina* zone from the Gulf Coast and considered it to be of

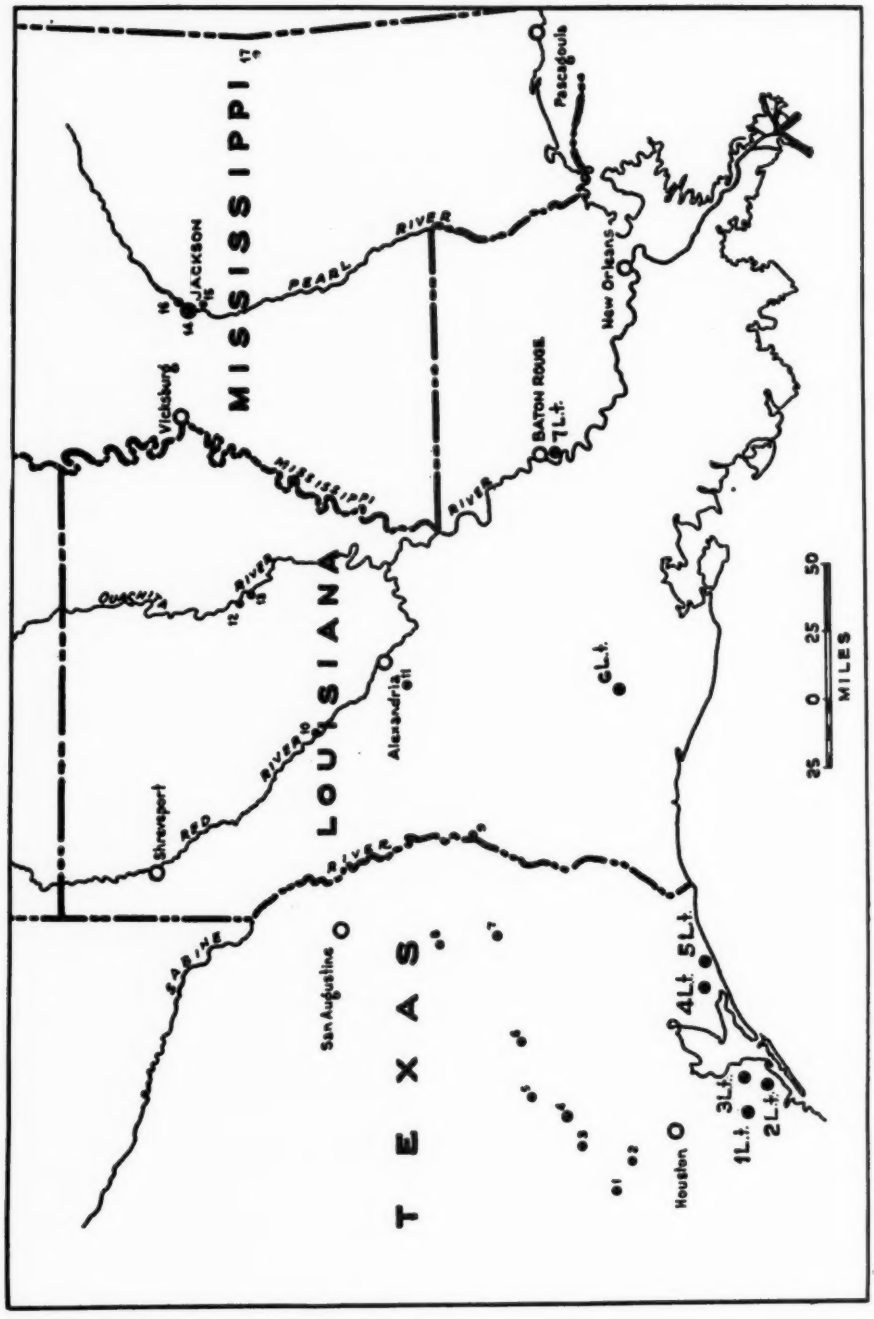

FIG. 1.—Numbers 1 to 17 are Moody's Branch marl localities after Gravell and Hanna (1935). Numbers 1 L.t. to 7 L.t. refer to a few wells in which *Lepidocyclina* (*Lepidocyclina*) *texana* Gravell and Hanna, n. sp., were found. (Modification of original map made by Mr. John S. Woods.)

middle Oligocene age. Subsequently, this zone has been cited many times in literature pertaining to the Gulf Coast, but so far as we are aware it has not been found at the surface, at least not definitely. The general stratigraphic relationships of the *Heterostegina* zone are fairly well known in the Gulf Coast west of Alabama, since it is present beneath the surface throughout much of this area. East of Mississippi its exact extent is not as well determined as in Texas and Louisiana; however, its correlatives east of Mississippi are debatable and consequently its relation to beds in the southeastern part of the United States is not discussed in this paper.

As originally defined, the *Heterostegina* zone consists of beds containing *Heterostegina* and lying between the *Discorbis* zone above and the *Marginulina* zone below. At the time the zone was described, only the relatively shallow water facies of the zone had been penetrated by the drill; consequently, only the shallow water facies could be used for description. Many wells have now reached this zone below a depth of 7,000 feet and these deeper wells show that the zone changes with depth or greater distance from the old shore line. The original zones have been subdivided in commercial work into numerous horizons not described in the literature. An example of the reason for investigation of these new horizons is the discovery of *Heterostegina* at depths up to several hundred feet below the top of the *Marginulina* zone. Evidently, *Heterostegina* is not as definitely restricted in the Gulf Coast as was formerly believed; there are changes basinward as well as laterally.

Lepidocyclina texana HORIZON

One of the horizons used in commercial laboratories is characterized by *Lepidocyclina* (*Lepidocyclina*) *texana* Gravell and Hanna, n.sp. In the examination of well samples,

---

ADDITIONAL WELLS IN WHICH *Lepidocyclina* (*Lepidocyclina*) *texana* HAS BEEN FOUND

1 L.t. Beaty, Bowles and Borsodi No. 1 Truska, Chas. O'Donnel Survey, Abstract A-497, located about 6 miles south of Alvin, Brazoria County, Tex. Samples examined from surface downward. First *Lepidocyclina* (*Lepidocyclina*) *texana* noted in cuttings from 7,660–7,690 feet.

2 L.t. Sun Oil Company's No. 1 Hughes, W. C. M. Baker Survey, Abstract A-28, located in the Green Lake oil field, southwest part of Galveston County, Tex. First *L.* (*L.*) *texana* noted were in cuttings from 8,724–8,754 feet.

3 L.t. Pan American Oil Company's No. 2 Craig, William K. Wilson Survey, Abstract A-208, located in the Gillock oil field, Galveston County, Tex. First *L.* (*L.*) *texana* noted were in cuttings from 7,230–7,260 feet.

4 L.t. Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Abstract A-460, Chambers County, Tex. First *L.* (*L.*) *texana* noted were in a core from 7,262–7,272 feet.

5 L.t. Magnolia Petroleum Company's No. 1 Hebert, P. H. Bell Survey, Abstract A-579, located about 4 miles east of Whites Station in the southwest part of Jefferson County, Tex. First *L.* (*L.*) *texana* noted were in cuttings from 9,350–9,352 feet.

6 L.t. Humble Oil and Refining Company's No. 4-B Devilbiss, sec. 11, T. 4 W., R. 9 S., Roanoke oil field, Jeff Davis Parish, La. First *L.* (*L.*) *texana* noted were in cuttings from 8,200–8,220 feet.

7 L.t. Superior Oil Company's No. 1 Duplantier, sec. 65, T. 1 W., R. 7 S., located just south of Baton Rouge, East Baton Rouge Parish, La. First *L.* (*L.*) *texana* noted were in a core from 7,860–7,874 feet.

made by Mr. John S. Woods.)

the sequence is examined from the shallowest to the deepest. That this is necessary is evident, since cuttings from a given depth may contain material from any bed through which the drill has passed. For this reason the first appearance of horizon markers is important for subsurface contour control. Up to the present time, however, *L.* (*L.*) *texana* is known only from a relatively thin zone (probably less than 50 feet thick). In general it appears about 200 feet below the first appearance of *Heterostegina*, as a suite of samples is examined. Study of additional wells will probably show that it occurs at a greater or somewhat lesser distance below the first appearance of *Heterostegina*, because of variation in the amount of material deposited between the tops of these two planes. In the wells so far examined the interval has been fairly uniform.

AGE AND CORRELATION OF THE *Heterostegina* ZONE AND *Lepidocyclina texana* HORIZON

Fortunately, the first appearance of *Heterostegina* in wells defines an approximate plane which can be found over a very extensive area. In this respect it is similar to the Moody's Branch of the Jackson Eocene (Gravell and Hanna, 1935). There is greater unanimity of opinion as to the correlation of these two horizons from well to well and area to area than in the case of any other horizons of younger Tertiary beds of the Gulf Coast. There is much difference of opinion, however, as to correlation of beds between these two horizons. This is due to marked changes in sedimentation in various areas of the Gulf Coast, due to relatively rapid changes from non-marine through brackish water and shallow marine, to fairly deep marine conditions seaward as well as parallel to the shore, with attendant ecologic variations and differences in faunas.

Very great difference of opinion prevails as to the equivalent of the *Heterostegina* zone in Florida, largely because *Heterostegina* has not been found there. Its apparent absence may be due to non-deposition, deposition and subsequent erosion, or ecological conditions not favorable for *Heterostegina*. The latter postulate appears to be least likely, but will require numerous carefully sampled wells through the southeasternmost part of the United States to settle the problem of *Heterostegina* zone correlation within the area. It is very doubtful if it can be settled from surface samples.

The age of the *Heterostegina* zone of the Gulf Coast in the original description was considered as follows:

> The presence of *Heterostegina antillea* Cushman in the marine Oligocene beds of Texas, correlates these beds with the Antigua formation of the West Indies, the type locality of the Middle Oligocene, in which this species of Foraminifera is the key fossil (Applin, Ellisor, Kniker, 1925, p. 101).

Heterostegina antillea Cushman was described from Long Island, Antigua, B. W. I. The syntypes were figured with the two specimens still imbedded in a rock specimen (Cushman, 1919, pl. 2, fig. 1*b*). In the same rock specimen are the syntypes of

Lepidocyclina undosa Cushman. In the Gulf Coast, *Lepidocyclina* (*Nephrolepidina*), apparently *L.* (*N.*) *undosa* Cushman, and *Lepidocyclina* (*Eulepidina*), apparently *L.* (*E.*) *favosa* Cushman, are very abundant in the Chickasawhay beds (see Note below) of Wayne County, Miss. While these specimens differ somewhat from the types, they appear to be within the limits of specific variation. It should be noted here, as pointed out by Vaughan (1924, p. 795), that the subgenera *Nephrolepidina* and *Eulepidina* grade into each other. *L.* (*Nephrolepidina*) *undosa* Cushman, as well as *L.* (*Eulepidina*) *favosa* Cushman, shows this intergradation.

NOTE.—The Bucatunna and overlying Chickasawhay strata were described from Wayne County, Miss., as two new members of Catahoula group and considered as Miocene in age. The Bucatunna member was believed to be separated from the Vicksburg group, immediately below, by an unconformity (Roy T. Hazzard and B. W. Blanpied: *Guidebook Eleventh Annual Field Trip, Shreveport Geol. Soc., into Southeast Mississippi*, 1934.) In a chapter by Hanna and Gravell (chart opposite p. 30 in Guidebook) the Limestone Creek beds (Chickasawhay) and Bucatunna were assigned formation rank and placed in a new group, the Limestone Creek group, considered as Oligocene in age. The Chickasawhay was considered in the text as probably equivalent in age to the Antigua formation, on the basis of occurrences of *Lepidocyclina favosa* Cushman and *Lepidocyclina undosa* Cushman.

The relationship of the Chickasawhay and Bucatunna to the Vicksburg was later discussed by C. Wythe Cooke (Notes on the Vicksburg group; *Am. Assoc. Petroleum Geologists, Bull.*, vol. 19, no. 8, pp. 1162–1172, 1935), who considered the Bucatunna and Chickasawhay as members of the Vicksburg group and as Oligocene in age.

Lepidocyclina is represented in the type Byram and the Glendon by forms which are very close to, if not identical, with, *L.* (*Nephrolepidina*) *undosa*. *L.* (*Lepidocyclina*) *supera* (Conrad) (1856, p. 74) is found in the Byram. Cole (1934, p. 23) has described *L.* (*L.*) *supera*, *L.* (*E.*) *favosa*, and *L.* (*N.*) *undosa* in the Glendon at Duncan Church, Fla. To the present we have not found *L.* (*L.*) *supera* in beds identified as Chickasawhay.

In the Chickasawhay are *Lepidocyclina* (*Lepidocyclina*) of the *L.* (*L.*) *cancellei* group. *L.* (*L.*) *colei* belongs to the *L.* (*L.*) *cancellei* group. We have not found stellate *Lepidocyclina* in the Chickasawhay, nor have species of *Lepidocyclina* been noted above *L.* (*L.*) *colei* and *L.* (*L.*) *texana* in the Gulf Coast. *Heterostegina* has not been found in beds which could be identified definitely as Chickasawhay, although it would not be surprising to find this genus in Chickasawhay or Vicksburg beds. *Heterostegina antillea* Cushman has not been found in the *Heterostegina* zone of the Gulf Coast.

From these observations it appears to us that as far as larger Foraminifera are concerned there is a clear relationship between the top of the *Heterostegina* zone and the base of the Vicksburg. It seems more logical to regard these beds as a series than to put strata of the Chickasawhay and *Heterostegina* zone, or even the latter, with the series above the *Heterostegina* zone.

The correlative of the *Heterostegina* zone in the European section is

doubtful and there is difference of opinion as to where the boundary between Miocene and Oligocene should be placed in Europe. *Lepidocyclina* occurs in beds considered to be Miocene in other parts of the world. These correlations, however, are made with areas in Europe where the Miocene-Oligocene question has not been settled to the satisfaction of all.

Considerable importance is attached to a reported stratigraphic break at the base of the Bucatunna beds. One of the sedimentary and ecologic breaks in the Gulf Coast occurs above the *Heterostegina* zone. The importance of these stratigraphic breaks probably is minimized or magnified according to the particular worker's viewpoint. We believe that study of the faunas indicates that the break above the *Heterostegina* zone is more important than the break at the base of the Bucatunna.

We believe that the question of placing the Miocene-Oligocene contact in the beds of the Gulf Coast is open. Due to the distance between North America and Europe, differences in sedimentation and ecologic conditions, and possible differences in crustal movements, it seems doubtful if the question will ever be settled satisfactorily to all who are intimately acquainted with the problem.

If the terms Miocene and Oligocene must be used in the Gulf Coast, we believe it more logical to consider the *Heterostegina* zone and associated beds, the Chickasawhay and associated beds, and the Vicksburg and associated beds as Oligocene, rather than part Oligocene and part Miocene. At the same time we welcome any additional information that will aid in definite establishment of this contact. Until sufficient opposing evidence is presented, we believe it best to follow established usage and consider the *Heterostegina* zone as a part of the Oligocene.

SYSTEMATIC DESCRIPTIONS

Family CAMERINIDAE

Genus OPERCULINOIDES Hanzawa, 1935

OPERCULINOIDES ELLISORAE Gravell and Hanna, n. sp.

Plate 60, figures 1–6

Test of moderate size, diameter, 2.34 mm., thickness, 0.54 mm., some specimens up to 2.7 mm. in diameter (vertical section pl. 60, fig. 6); rather thinly lenticular, tending to terminate in a slight flange; periphery fairly sharply rounded; surface unornamented; chamber sutures visible but not raised, sutures broadly curved irregularly for about two-thirds of the distance to the periphery from the proximal ends, then recurved broadly backward; vertical section shows about four whorls with walls of nearly uniform thickness from center to periphery, alar projections of chambers ending nearly over center of test with coalesence of

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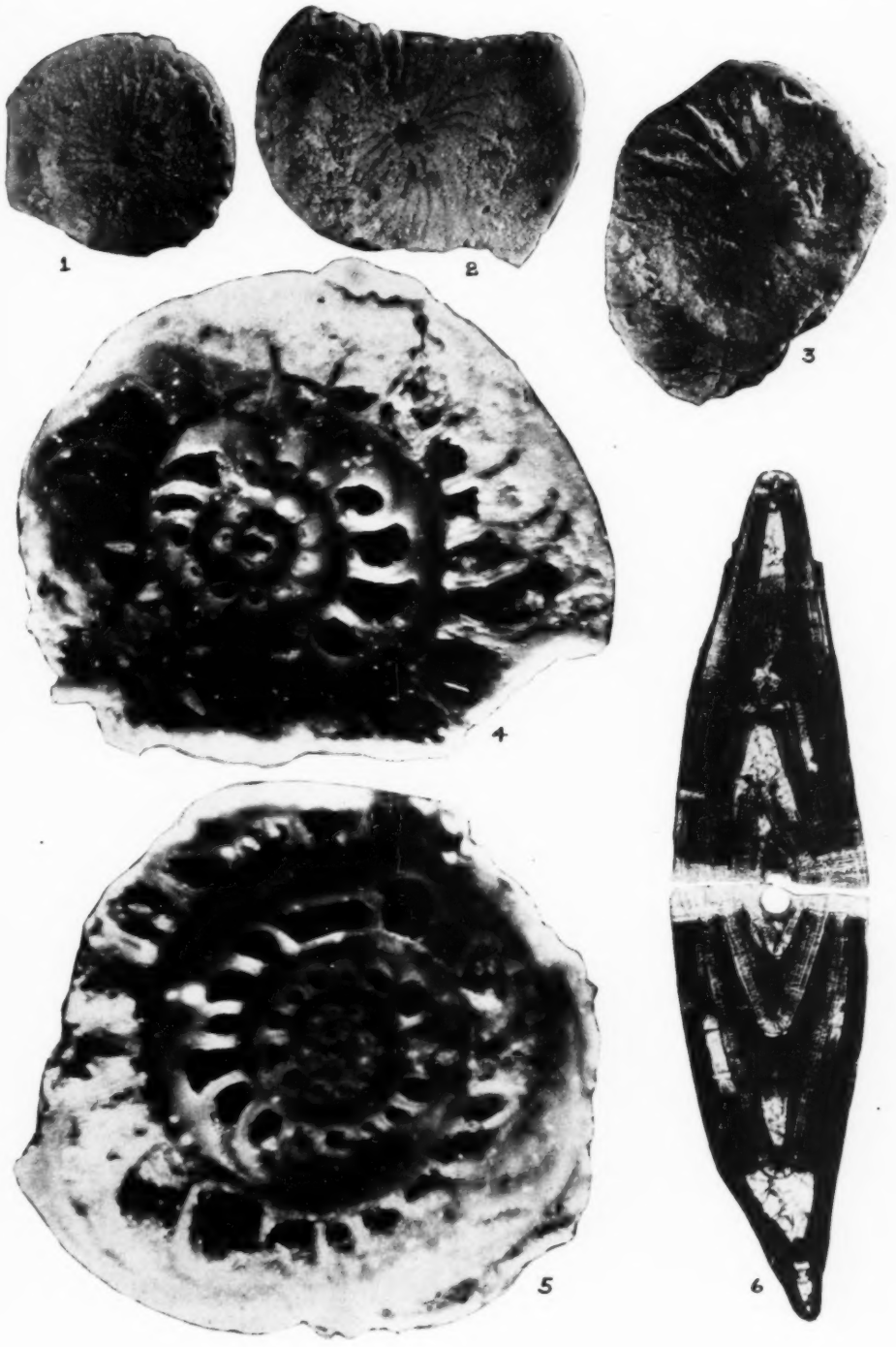
EXPLANATION OF PLATE 60

All specimens from core at 7,356–7,366 feet in Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Chambers County, Tex.

FIGS. *1–6—Operculinoides ellisorae* Gravell and Hanna, n. sp., syntypes. *1–3*, Surface views, ×18; *4, 5*, half sections through median plane, ×50; *6*, vertical thin section, ×50.

(p. 522)



Gravell and Hanna, Tertiary Foraminifera

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the whorls into a cone of solid shell material over the initial chambers; initial chamber about 80 μ in diameter. One horizontal section (pl. 60, fig. 4) shows initial chamber about 80 μ in diameter; second chamber apparently slightly smaller; first whorl exclusive of the two initial chambers containing about 7 chambers, second about 11 chambers, third about 17 chambers. Another horizontal section (pl. 60, fig. 5) contains about four and one-half whorls, has an initial chamber about one-half the size of that in the section previously mentioned, or about 40 μ in diameter; diameter of second chamber apparently of about equal size; number of chambers in first to third whorl uncertain, but apparently about the same as in the section shown in pl. 60, fig. 4; fourth whorl with about 20 chambers. Final whorl (pl. 60, fig. 3) shows 22 to 24 chambers.

Remarks.—*Operculinoides ellisorae* differs from *Operculinoides howei* Gravell and Hanna, n. sp., in being much flatter, in its more rapidly widening of whorls, and in its tendency for the last whorl to be flanged. Named in honor of Miss Alva C. Ellisor.

Occurrence.—Syntypes from Loc. 4 L.t., core at depth 7,356–7,366 feet. Associated with *Operculinoides howei*, *Heterostegina israelskyi*, *H. texana*, *Lepidocyclina* (*Lepidocyclina*) *colei*, and *L.* (*L.*) *texana*. From *Lepidocyclina texana* horizon of the *Heterostegina* zone, Oligocene.

Types.—Syntypes to be deposited in U. S. Nat. Mus.

OPERCULINOIDES HOWEI Gravell and Hanna, n. sp.
Plate 61, figures 2–6

Test of moderate size (vertical section, pl. 61, fig. 4, shows diameter 2.34 mm., thickness 1.0 mm.); thickly lenticular; periphery rounded; surface smooth, slightly rough on central area; sutures on surface only slightly curved to two-thirds to four-fifths of distance from proximal ends where they recurve sharply, sutures not raised; vertical section (pl. 61, fig. 4) shows about five whorls, walls thick, but thinning slightly toward periphery and coalescing on both sides over initial chambers to form a cone of solid shell material; cone has an angle of about 30 to 35 degrees, so that alar prolongations of chambers are well developed; diameter of initial chamber about 80 μ. Horizontal section, pl. 61, fig. 6, not cut exactly through center, shows initial chamber probably about 100 μ in diameter; second chamber apparently slightly smaller; first whorl exclusive of the two embryonic chambers with about 9 chambers; second about 12 chambers; third, about 15 chambers; and fourth, about 19 chambers; since the surface of our specimens is rather poorly preserved, the number of chambers in the final whorl is difficult to count accurately.

Remarks.—*Operculinoides howei* differs from *O. ellisorae* in its much greater thickness (1.0 mm. as contrasted to 0.54 mm.) and less rapidly expanding whorls. No suggestion of a flange was noted in *O. howei*. No specimens of *O. howei* with smaller embryonic chambers were noted. *Operculinoides ellisorae* and *O. howei* differ from *O. antiguensis* Vaughan and Cole (1936, p. 492, pl. 38, figs. 7–10) in being smaller and thinner. They differ from *O. tuxpanicus* Vaughan and Cole (1936, p. 494, pl. 37, figs. 4–9) in being thicker and less flanged. *O. howei* also has a heavier test. They differ from *O. forresti* Vaughan and Cole (1936, p. 493, pl. 37, figs. 1–3) in being thicker and unornamented. They differ from *O. panamensis* (Cushman) (1918, p. 98, pl. 43, figs. 9, 10) in being larger and more robust. In vertical section *O. howei* resembles *O. parvula* (Cushman) (1919, pp. 24, 51, pl. 4, figs. 3–6) from St. Bartholomew, Leeward Islands, B. W. I., in general size, thickness of test, and of shell wall, but because the surface characteristics and number of chambers of *O. parvula* are not known, *O. howei* can not be said to be the same. *O. parvula* is an Eocene species.

Operculinoides howei and *O. ellisorae* were compared with a large suite of *Operculinoides* from the type Byram marl. Both *O. vicksburgensis* Vaughan and Cole (1936, p. 490, pl. 36, figs. 1–6) and *O. dia* (Cole and Ponton) (1930, p. 37, pl. 6, fig. 7; pl. 7, figs. 11–13) are present in the material. In the Gulf Coast the Bryam marl contains very abundant specimens of *Operculinoides*. *O. howei* and *O. ellisorae* are close to *O. vicksburgensis* and *O. dia*, respectively, but differ in being thicker and in having heavier shell walls.

O. howei is close to *O. semmesi* Vaughan and Cole (1936, p. 491, pl. 37, figs. 10–13, probably fig. 14; pl. 38, figs. 1, 2, probably figs. 5, 6). *O. semmesi* has a "slightly extended thinner edge in fully adult perfect specimens," while *O. howei* does not. Raised sutures, such as are present on *O. semmesi*, were not found on *O. howei*. Apparently there are fewer whorls in *O. semmesi* than in *O. howei*. In *O. howei* the recurvature of the sutures appears to start nearer the periphery.

Named in honor of Dr. Henry V. Howe.

Occurrence.—Syntypes from Loc. 4 L.t., core at depth of 7,356–7,366 feet; *Lepidocyclina* horizon of *Heterostegina* zone, Oligocene.

Types.—Syntypes to be deposited in U. S. Nat. Mus.

Genus HETEROSTEGINA d'Orbigny, 1826

HETEROSTEGINA ISRAELSKYI Gravell and Hanna, n. sp.

Plate 62, figures 1–4.

Heterostegina antillea CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, pp. 49, 50, pl. 2, fig. 1*b*, pl. 5, figs. 1, 2. (Also part in many references to Gulf Coast *Heterostegina*.)

Test medium size, very slightly umbonate, length from unfigured specimens up to about 4.25 mm., width about 3.0 mm., slightly thickened in area over embryonic apparatus, surrounded by a wide thin flange, chamber and chamberlet walls slightly raised on surface of test; test thin, thickest through the embryonic apparatus where it is about 0.35 mm., decreasing gradually to about 0.2 mm., at a distance of about 0.5 mm. from center of umbo which is eccentrically located and not prominent; thickness of flange of test approximately 0.2 mm.

Embryonic apparatus of megalospheric form (pl. 62, fig. 3) consists of an initial chamber, circular in horizontal section, having a diameter of about 67 μ, followed by a kidney-shaped second chamber having a maximum diameter of about 0.11 mm. and a minimum diameter of about 48 μ.

A horizontal section of microspheric form (pl. 62, fig. 1) shows embryonic chambers much smaller than in megalo-

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EXPLANATION OF PLATE 61

All specimens from core at 7,356–7,366 feet in Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Chambers County, Tex.

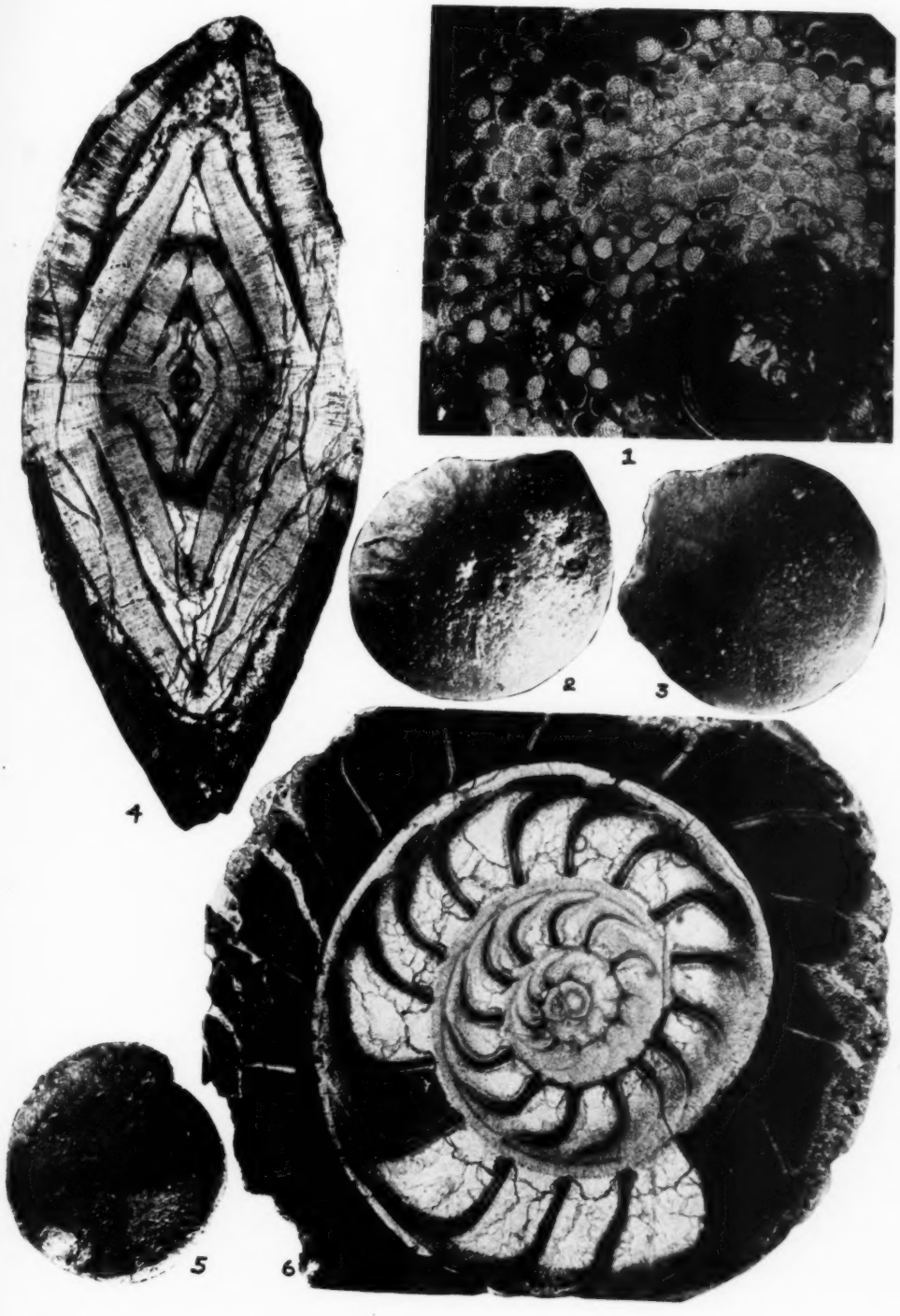
FIG. *1*—*Lepidocyclina* (*Lepidocyclina*) *colei* Gravell and Hanna, n. sp., syntype. Thin section in median plane to show pores in roofs of equatorial chambers, ×50. (p. 526)

2–6—*Operculinoides howei* Gravell and Hanna, n. sp., syntypes. *2*, *3*, Surface views, ×18; *4*, vertical thin section, ×50; *5*, surface view, ×18; *6*, thin section in median plane, ×50. (p. 523)

EXPLANATION OF PLATE 62

All specimens from core at 7,336–7,346 feet in Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Chambers County, Tex.

FIGS. *1–4*—*Heterostegina israelskyi* Gravell and Hanna, n. sp., syntypes. *1*, Thin section in median plane of microspheric form, ×50; *2*, vertical thin section, megalospheric form, ×50; *3*, thin section in median plane of megalospheric form, ×50; *4*, surface view, ×18. (p. 524)



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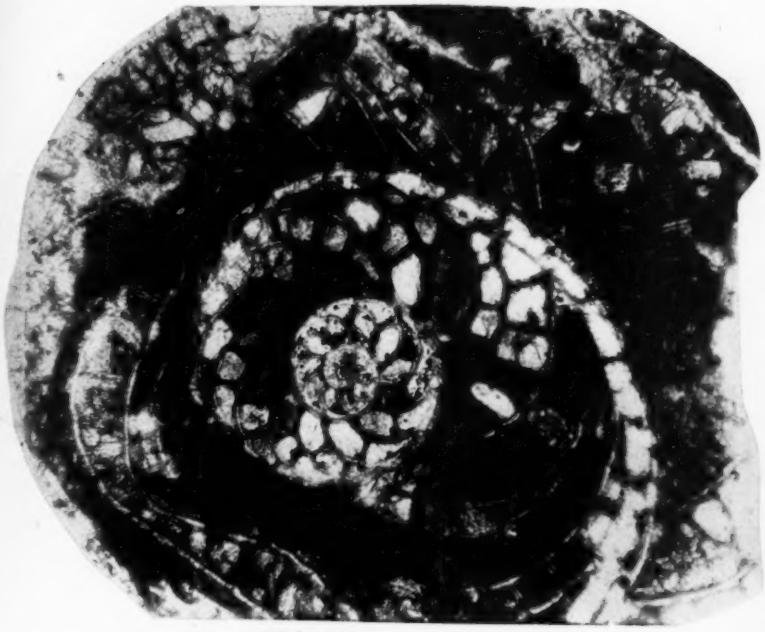

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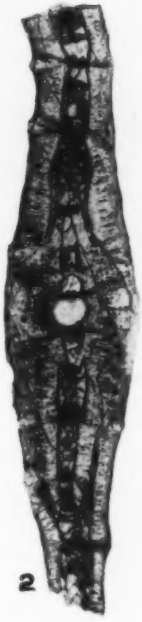

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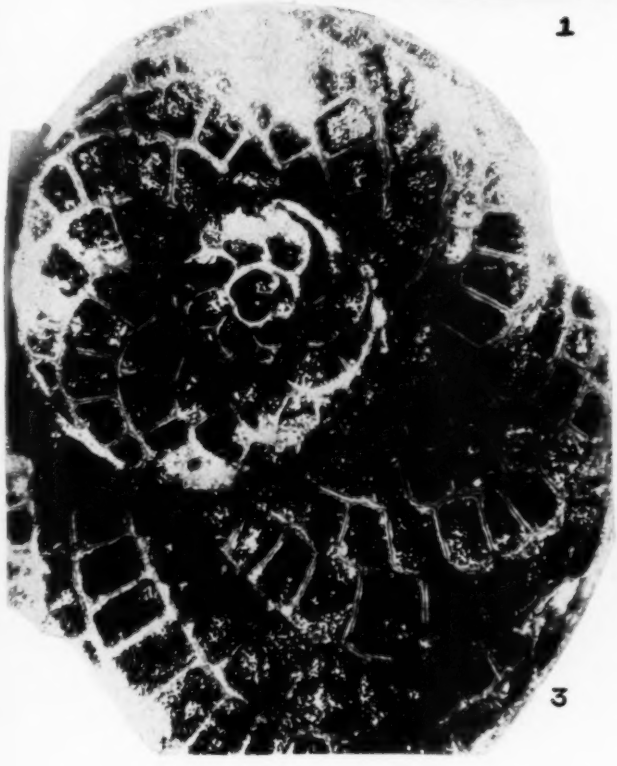

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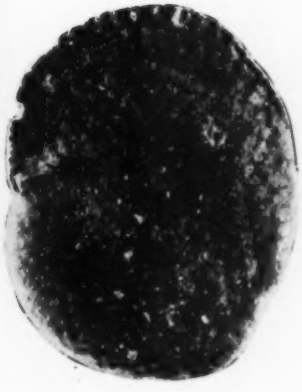

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spheric form; about two whorls of chambers that are not subdivided, these two whorls containing 15 to 20 chambers, whereas in the megalospheric form apparently not more than the first four chambers are undivided into chamberlets.

Remarks.—*Heterostegina israelskyi* differs from the other described species of American *Heterostegina* in the thinner and more fragile character of the test. Named in honor of Mr. Merle C. Israelsky.

Occurrence.—Syntypes from Loc. 4 L.t., core at depth of 7,336–7,346 feet, *Lepidocyclina texana* horizon of *Heterostegina* zone, Oligocene.

Types.—Syntypes to be deposited in U. S. Nat. Mus.

HETEROSTEGINA TEXANA Gravell and Hanna, n. sp.

Plate 63, figures 1–4

Heterostegina antillea CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, pp. 49, 50, pl. 2, fig. 1*b*, pl. 5, figs. 1, 2. (Also part in many references to Gulf Coast *Heterostegina*.)

Test medium size, greater diameter up to 4.4 mm., small diameter up to about 3.1 mm. (pl. 63, fig. 2); thickness through embryonic apparatus up to about 0.75 mm. (pl. 63, fig. 3); thickness through flange about 0.25 mm. Test composed of about three and one-half whorls; initial chamber nearly circular in horizontal section, being about 140 μ in diameter; second chamber kidney-shaped, minimum diameter about 100 μ maximum diameter about 200 μ; third chamber not subdivided; fourth and successive chambers subdivided into chamberlets (pl. 63, figs. 1, 4).

Vertical section (pl. 63, fig. 3) shows test to be thickest over embryonic apparatus, which is eccentrically located, due to rapid increase in width of whorls; chamber roofs and floors thick, about twice as thick as chamber walls are high; in vertical section, test has form of a low broad biconvex lens surrounded by a flange; periphery of test broadly rounded.

Surface of test marked by sutures of chambers and chamberlets which are slightly raised; center of umbo composed of clear shell material formed by the coalescing of chamber sutures.

Remarks.—*Heterostegina texana* differs from *H. antillea* Cushman in that the thickened portion of the test is larger, occupying about two-thirds of the diameter of the test, whereas the umbonate portion of *H. antillea* occupies only about one-third of the test diameter. *H. antillea* is somewhat larger than *H. texana*, since the former may be as large as 6.0 mm.

H. texana has been referred to in numerous places in the literature of the Gulf Coast as *H. antillea*. The syntypes of *antillea* are from older rocks than those which contain *texana*. *H. antillea* was described by Cushman from U. S. Geol. Survey, sta. 6868, Long Island, Antigua, B. W. I. Described at the same time and figured in the same rock specimen was *Lepidocyclina undosa* Cushman (1919, p. 65, pl. 2, fig. 1*a*). Thus, the syntypes of *H. antillea* and *L. undosa* occur not only at the same locality but in the same rock specimen. We have found in the Chickasawhay (Limestone Creek beds) of Mississippi and Alabama numerous occurrences of a *Lepidocyclina* which is very close to, if not identical with, *L. undosa*, but to date have not found any *Heterostegina* associated with them. *Heterostegina* does occur in Mississippi and Alabama but above the Chickasawhay.

H. texana is approximately one-third larger than *H. panamensis* Gravell (1933, p. 17, pl. 1, figs. 10, 11) and it occurs in a higher stratigraphic horizon. The whorls of *H. texana* also widen almost twice as rapidly as those of *H. panamensis*, and it differs from *H. panamensis* in that the initial chambers are smaller.

H. texana differs from *H. ocalana* Cushman (1921, p. 130, pl. 21, figs. 15–18) and the variety *H. ocalana* var. *glabra* Cushman (1921, p. 131, pl. 21, fig. 19) in both size and sculpturing.

Occurrence.—Syntypes from Loc. 4

L.t., core at depth of 7,356–7,366 feet; *Lepidocyclina texana* horizon of *Heterostegina* zone, Oligocene.

Types.—Syntypes to be deposited in U. S. Nat. Mus.

Family ORBITOIDIDAE

Genus LEPIDOCYCLINA Gümbel, 1868

LEPIDOCYCLINA (LEPIDOCYCLINA) COLEI Gravell and Hanna, n. sp.

Plate 61, figure 1; Plate 63, figure 5; Plate 64, figures 1–6

Test small, flatly lenticular with a low wide dome and a slight suggestion of a narrow marginal flange; diameter of largest specimen (unfigured) about 4.0 mm. but this has a part of the edge broken off,—unbroken its diameter would be about 4.5 to 5.0 mm.; thickness of adult specimens, 0.7 to 1.0 mm. or about one-seventh to one-fifth of the diameter, thickness decreasing gradually from center to periphery, some specimens showing slight suggestion of a narrow poorly developed flange (as the margins of our specimens are somewhat broken we are not certain of this feature; at least the flange, if present, is not prominent); papillae obscure to moderately prominent (pl. 64, figs. 2–4), ranging in size from 55 μ to 170 μ in diameter, those over center of test being largest.

Embryonic apparatus thick-walled, ellipsoidal, composed of two nearly equal chambers separated by a straight wall. In two of the syntypes (pl. 64, figs. 1, 5 respectively), greatest diameters of embryonic apparatus, including wall, 0.40 and 0.36 mm., excluding wall, 0.33 and 0.28 mm.; lesser diameters, including wall, 0.36 and 0.29 mm., excluding wall, 0.26 and 0.22 mm. Wall of embryonic apparatus thick, about 0.04 mm. Vertical section (pl. 64, fig. 4) shows embryonic apparatus to be ellipsoidal, horizontal diameter, including wall, about 0.34 mm., excluding wall, about 0.25 mm.; height, including wall, about 0.26 mm., excluding wall, about 0.17 mm. On each side of the junction of the embryonic chambers is a chamber about 110 μ long and 50 μ wide. These two chambers are about twice size of remaining equatorial chambers that surround the embryonic apparatus.

The equatorial chambers in horizontal sections (pl. 63, fig. 5; pl. 64, figs. 1, 5) vary; those near center of test have curved outer walls and converging inner walls (average radial and transverse diameters are about 55 μ and 75 μ respectively); those in central portion, regular hexagonal (average diameter about 60 to 70 μ); those near periphery with rounded outer walls and parallel side walls (radial diameters, 75 to 100 μ, transverse diameters, 65 to 75 μ); roofs and floors minutely perforated (pl. 61, fig. 1).

In vertical section, equatorial chambers are about 40 μ high near embryonic

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EXPLANATION OF PLATE 63

All specimens from core at 7,366–7,376 feet in Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Chambers County, Tex.

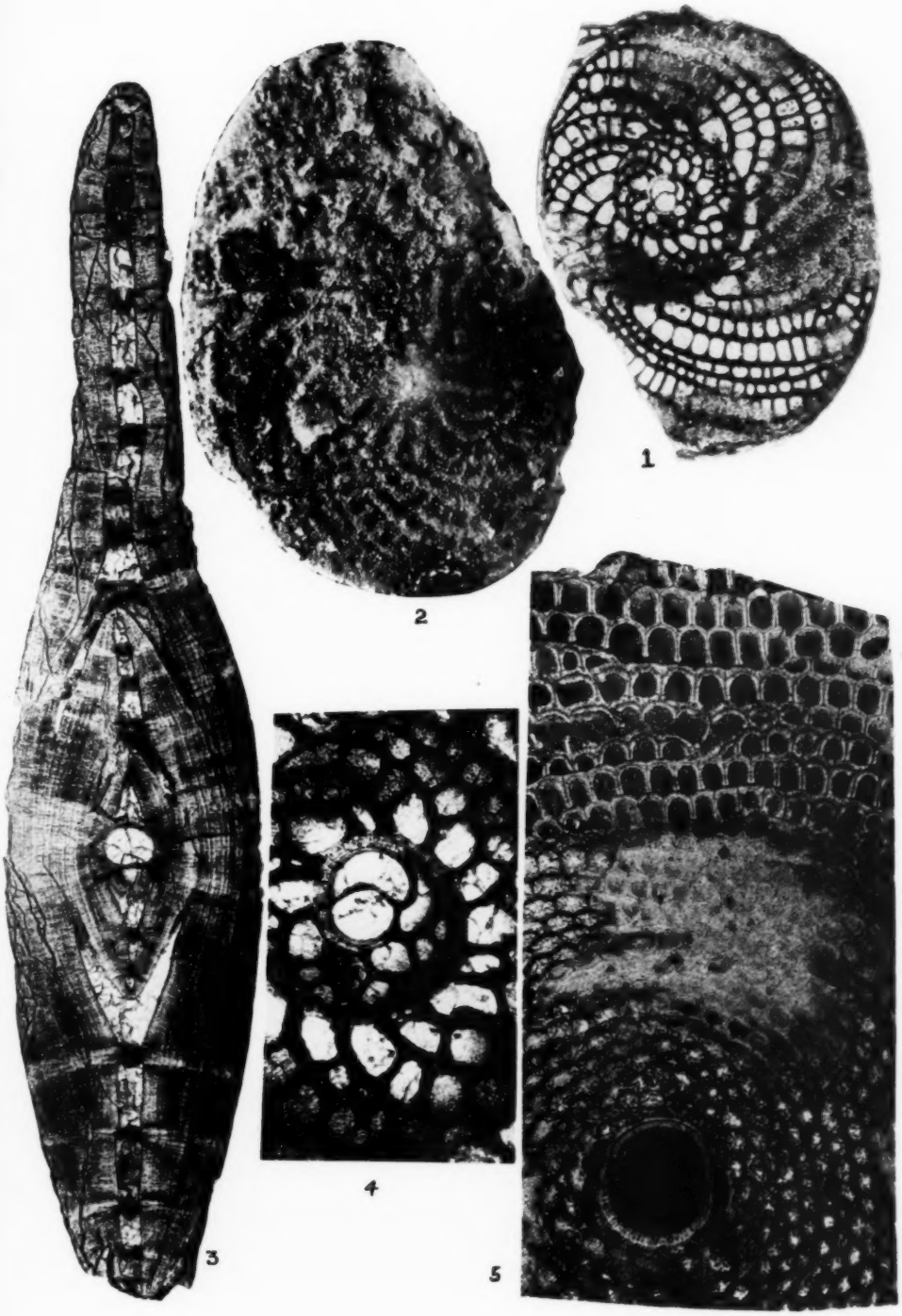
FIGS. *1–4—Heterostegina texana* Gravell and Hanna, n. sp., syntypes. *1*, Thin section in median plane, ×18; *2*, surface view, ×18; *3*, vertical thin section, ×50; *4*, enlargement of figure *1* to show character of embryonic chambers, ×50. (p. 525)

5—Lepidocyclina (Lepidocyclina) colei Gravell and Hanna, n. sp., syntype. Thin section in median plane, ×50. (p. 526)

EXPLANATION OF PLATE 64

All specimens from core at 7,366–7,376 feet in Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Chambers County, Tex.

FIGS. *1–6—Lepidocyclina (Lepidocyclina) colei* Gravell and Hanna, n. sp., syntypes. *1*, Half section cut in median plane, ×50; *2*, surface view, ×18; *3*, view of surface of specimen shown in fig. *1*, ×18; *4*, vertical thin section, ×50; *5*, half section cut in median plane, ×50; *6*, view of surface of specimen shown in fig. *5*, ×18. (p. 526)



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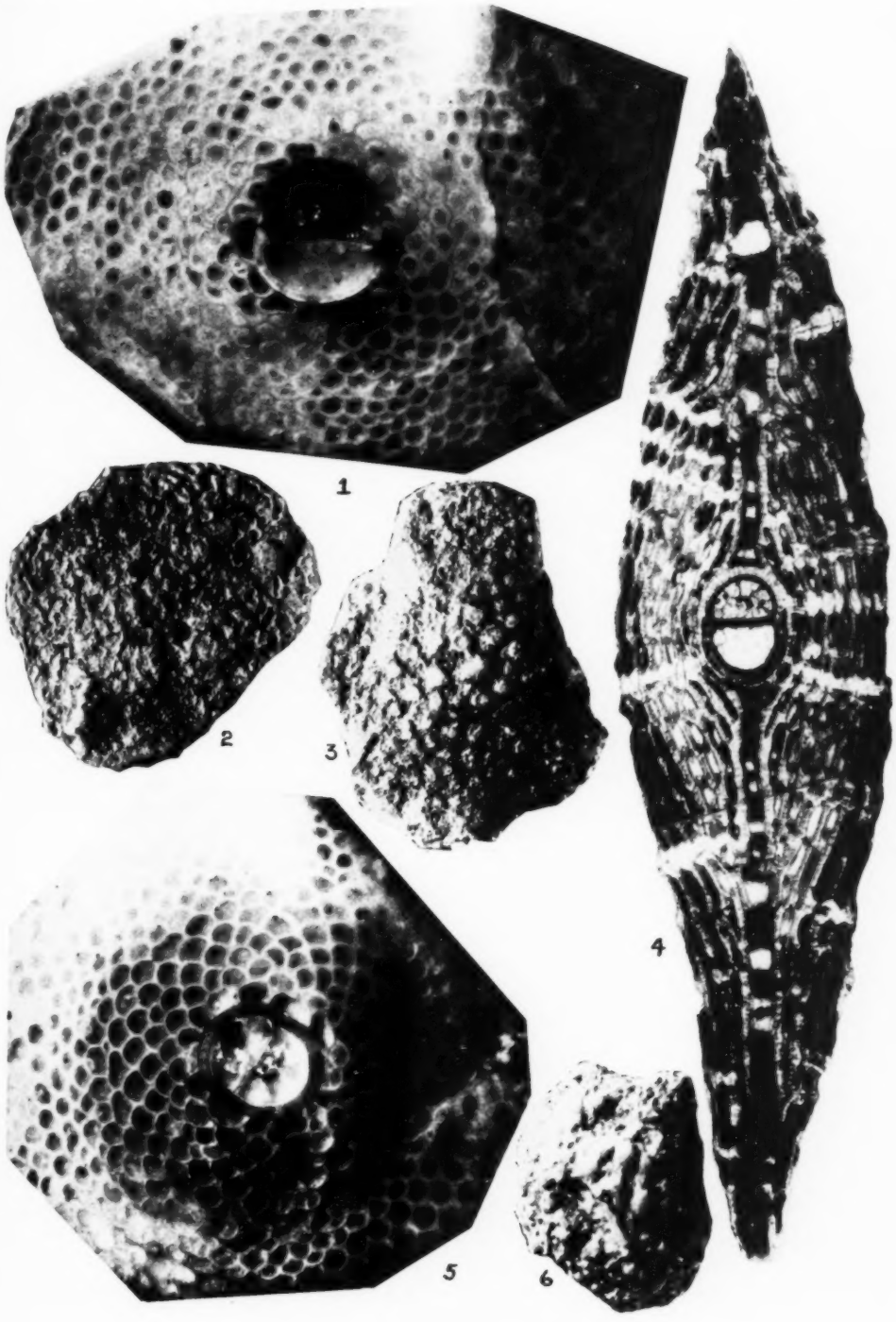

Gravell and Hanna, Tertiary Foraminifera

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apparatus, increasing gradually in height to about 85 μ at a distance of 1.7 mm. from center of test; roofs and floors of equatorial chambers about 20 μ thick.

The lateral chambers in adult specimens consist of about ten layers over center of test (pl. 64, fig. 4), decreasing gradually to probably none over the equatorial layer at periphery; arranged in fairly definite tiers; elongate and increasing in length toward surface, those nearest embryonic apparatus about 60 μ long, increasing to about 130 μ near surface. Average height of chamber spaces and roofs about 40 μ, but near embryonic apparatus chamber space and roof approximately equal, whereas near surface of test the height of chamber is about three times as great as thickness of roof. Pillars fairly prominent, formed by overlapping ends of lateral chambers.

Remarks.—*Lepidocyclina* (*Lepidocyclina*) *colei* differs from *L.* (*L.*) *antiguensis* Vaughan and Cole (1933, p. 19, pl. 10, fig. 8; pl. 24, figs. 2, 3), *L.* (*L.*) *giraudi* R. Douvillé (Vaughan and Cole, 1933, p. 20, pl. 10, figs. 9, 10; pl. 24, fig. 4), and *L.* (*L.*) *parvula* Cushman var. *crassicosta* Vaughan and Cole (1933, p. 17, pl. 8, figs. 1, 2; pl. 10, fig. 7; pl. 24, fig. 1) in not being costate, as well as being a thinner species. It differs from *L.* (*L.*) *yurnaguensis* Cushman (1919, p. 57, pl. 12, figs. 7, 8, text fig. 6), described as *L.* (*L.*) *canellei* var. *yurnaguensis* Cushman but elevated to specific rank by Vaughan (1926, p. 391, pl. 25, figs. 2–6), in being a thinner species. It differs from *L.* (*L.*) *parvula* Cushman (1919, p. 58, pl. 3, figs. 4–7) in being thinner, less umbonate and less flanged, and generally in having fewer, smaller and less prominent pillars. It differs from *L.* (*L.*) *forresti* Vaughan (1927, p. 1, pl. 1, figs. 1–4; pl. 2, figs. 1–6) in being more uniformly lenticular. *L.* (*L.*) *forresti* also has an umbo of smaller diameter and a wide thin flange. It differs from *L.* (*L.*) *canellei* Lemoine and R. Douvillé (1904, p. 20, pl. 1, fig. 1; pl. 3, fig. 5) in having prominent pillars. *L.* (*L.*) *colei* is also a thinner species. It differs from *L.* (*L.*) *miraflorensis* Vaughan (1923, p. 257) in being more uniformly lenticular. *L.* (*L.*) *miraflorensis* is broadly umbonate but with a well-developed flange. *L.* (*L.*) *colei* is apparently closely related to *L.* (*L.*) *pancanalis* Vaughan and Cole (1932, p. 510, figs. 1–9), but differs in being thinner and having better developed pillars. It differs from *L.* (*L.*) *waylandvaughani* Cole (1928, p. 221, pl. 35, figs. 1–10) in being thicker and more uniformly lenticular. *L.* (*L.*) *waylandvaughani* has a small umbo and a wide fairly thin flange.

Occurrence.—Syntypes from Loc. 4 L.t., core at depth of 7,356–7,366 feet; *Lepidocyclina texana* horizon of *Heterostegina* zone, Oligocene.

Types.—Syntypes to be deposited in U. S. Nat. Mus.

LEPIDOCYCLINA (LEPIDOCYCLINA) TEXANA Gravell and Hanna, n. sp.

Plate 65, figures 1–7

Test stellate, five-rayed, maximum diameter about 7.0 mm., diameter of inter-ray area 3.5 to 4.0 mm., length of rays measured from center of test about 3.5 mm.; test rather thin, thickest in center where it is slightly peaked, and about 1.3 mm. thick; thickness along center of rays decreases to about 0.7 mm. at a distance of about 1.0 mm. from center of test and then gradually decreases to the ends of the rays; thickness in inter-ray areas decreases rapidly for about one-half of radius of inter-ray area, then slowly forms a flange in the inter-ray areas; this flange extends out to about one-half the length of rays but decreases rapidly in width toward the extremities of rays.

Surface of test finely papillate, papillae vary from 50 μ to 125 μ in diameter, interspaces approximately equal to diameters of papillae; diameter of those in center of test and along the center of rays being largest.

Embryonic apparatus thick-walled, slightly ellipsoidal, but nearly circular in horizontal section; composed of two

nearly equal chambers, which are separated by a straight wall. In the syntype (pl. 65, fig. 1) diameter of embryonic apparatus, including wall and measured parallel to septum, 0.533 mm., excluding wall, 0.44 mm.; diameter at right angle to septum, including wall, about 0.571 mm., excluding wall, about 0.484 mm. Wall of embryonic apparatus about 0.043 to 0.047 mm. thick. Vertical section (pl. 65, fig. 2) shows embryonic apparatus to be ellipsoidal, horizontal diameter, including wall, about 0.552 mm., excluding wall, 0.466 mm; height including wall, about 0.493 mm., excluding wall, about 0.386 mm.

Equatorial chambers in general have rounded outer walls and converging inner walls, curve of outer wall varying from regularly rounded in inter-ray areas to elongate on rays; equatorial chambers about equal in area, although shape is slightly different, radial diameters varying from 80 to 90 μ and transverse diameters from 85 to 100 μ; roofs and floors of equatorial chambers minutely perforated (pl. 65, fig. 3).

In a vertical section (pl. 65, fig. 2), cut along center of a ray on one side of the embryonic apparatus and through the inter-ray area on the other side, equatorial chambers are about 50 μ in height near embryonic apparatus and about 200 μ in height at a distance of 3.5 mm. from center of test along a ray, but are only about 100 μ in height at a distance of 2.0 mm. from center in inter-ray area; roofs and floors of the equatorial chambers thin in inter-ray areas (about 10 to 15 μ) but thick on rays, having a maximum thickness of about 100 μ.

Lateral chambers consist of about 11 layers over center of test (pl. 65, fig. 2), but decrease gradually in number to none over the equatorial layer at edge of flange bordering the rays (pl. 65, fig. 6). Lateral chambers arranged in fairly definite tiers, although more irregularly arranged immediately over rays. Lateral chambers only slightly longer than high, increasing slightly in length toward surface of test, length of those nearest embryonic apparatus about 80 μ, increasing to a maximum of about 110 μ near surface; average height of lateral chambers varies from about 20 μ near embryonic apparatus to about 40 or 50 μ in some near surface; average thickness of chamber roofs about 20 μ in inter-ray areas and up to 40 μ on rays. Pillars fairly prominent, formed by overlapping ends of lateral chambers.

The section shown in pl. 65, fig. 6 is cut across a ray at about the middle. In it the equatorial layer of chambers is thickest near center of ray but it thins to about one-half this thickness in the bordering flanges; pillars prominent. Several layers of lateral chambers over center of ray, but decrease rapidly in number to none over equatorial layer of the flanges.

Remarks.—*Lepidocyclina* (*Lepidocyclina*) *texana* differs from *L.* (*L.*) *asterodisca* Nuttall (1932, p. 34, pl. 7, figs. 5, 8; pl. 9, fig. 10), described from the lower Oligocene of the Tampico Embayment of Mexico, in being somewhat larger and thicker, and five- instead of four-rayed. In *L.* (*L.*) *texana* the embryonic chambers are nearly equal in size, whereas in *L.* (*L.*) *asteordisca* they are only subequal; they are also larger in *L.* (*L.*) *texana*. *L.* (*L.*) *texana* differs

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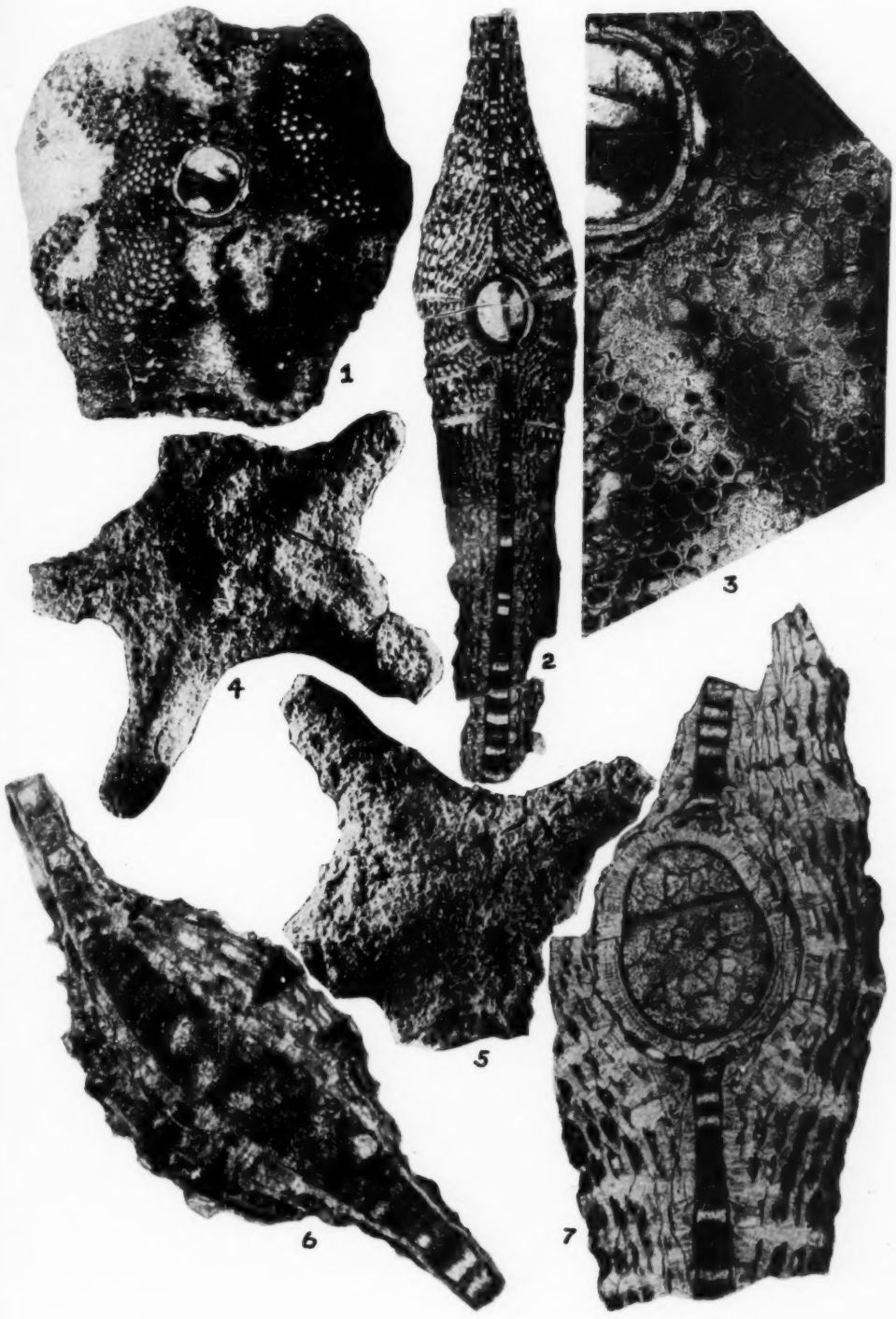
EXPLANATION OF PLATE 65

All specimens from the Sun Oil Company's No. 1 Hamilton, J. T. White Survey, Chambers County, Tex.

FIGS. *1–7*—*Lepidocyclina* (*Lepidocyclina*) *texana* Gravell and Hanna, n. sp., syntypes. *1*, Thin section cut in median plane, from core at 7,366–7,376 feet, ×18; *2*, vertical thin section, from core at 7,366–7,368 feet, ×18; *3*, enlargement of fig. *1* to show pores in equatorial chamber roofs, ×50; *4*, *5*, surface views, from core at 7,366–7,368 feet, ×10; *6*, thin section cut across one of the rays, from core at 7,366–7,376 feet, ×50, *7*, vertical thin section, from core at 7,366–7,376 feet, ×50. (p. 527)



Gravell and Hanna, Tertiary Foraminifera

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from *L.* (*L.*) *wetherellensis* Vaughan and Cole (1933, p. 24, pl. 12, figs. 6, 7; pl. 23, figs. 9, 10; pl. 24, fig. 5), from the middle Oligocene of Antigua, B. W. I., in being decidedly rayed, whereas in the latter there are eight irregularly spreading rays which produce only a lobate outline. *L.* (*L.*) *texana* differs from *L.* (*L.*) *falconensis* Gorter and van der Vlerk (1932, p. 105, pl. 11, figs. 4–6) in being much more distinctly rayed.

Occurrence.— Syntypes from Loc. 4 L.t., are at depth of 7,366–7,376 feet; *Lepidocyclina texana* horizon of *Heterostegina* zone, Oligocene.

Types.—Syntypes to be deposited in U. S. Nat. Mus.

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PALEONTOLOGICAL NOTES

NOTES ON *MARGINULINA VACAVILLENSIS* (HANNA)

G. D. HANNA AND C. C. CHURCH

In 1923 Hanna reported on a collection of Foraminifera which had been collected in Ulatis Creek, about 3 or 4 miles north of Vacaville, Solano County, Calif. Comparative material was then very scarce on the Pacific Coast and the technique of preparation was not well known. In the paper (Hanna, G. D., 1923, p. 324, pl. 59, figs. 4*a*, 4*b*) there was described a specimen called "*Cristellaria vacavillensis*" which is now known, from abundant material from the same outcrop, to be incomplete. Later chambers have been broken off, thus disfiguring the aperture. Adult specimens show that the aperture has the typical produced, elongate-radiate form of this group of species. Moreover, the later chambers become disconnected from the body whorl and extend a distance at least equal to the major diameter.

A more fully grown form of this species, but still not adult, was later described and figured by Cushman and G. D. Hanna (1927) as "*Cristellaria mexicana nudicostata*" from Eocene shales near Coalinga, Calif. Under this name the form has been referred to in several later papers. Cushman and M. A. Hanna (1927) illustrated a specimen as "*Robulus mexicanus* Cushman var. *nudicostatus*" which is just beginning to show the uncoiled condition.

The purpose of the present note is to call attention to the synonymy and to indicate the apparent relationship of similar forms.

In comparing the above species with forms closely related to it, the species originally described by Doctor Cushman as *Cristellaria mexicana* (1925) was examined. It is closely related to *Marginulina vacavillensis*, but is separable on the basis of its more nodose umbilical area and more carinate periphery, the last feature of which gives it a flatter appearance with a more circular outline.

"*Cristellaria*" *saundersi* Hanna and Hanna (1924), though closely related to *M. vacavillensis* is more elongate, more heavily sutured and has a definite carina on the inner uncoiled edge. In the California Eocene this species is found in the lower part of the Tecuya Creek Tejon near the type locality. An undescribed form more closely related to *M. vacavillensis* is present in the top of the Tejon section in the first canyon east of Tecuya Creek. Its raised sutures are broken into nodes. *Marginulina fragaria* (Gümbel) var. *texasensis* (Cushman and Applin) (Cushman, 1935) is similar in general outline to *M. vacavillensis* but is heavily noded over the sutures rather than having single high ribs. "*Cristellaria*" *asperuliformis* Nuttall (1930), described from the Aragon, Mexican Eocene, is also a heavily-noded form.

Of the forms described recently and correctly identified with the species under discussion are Nuttall's "*Cristellaria*" *mexicana* Cushman var. *nudicostata* Cushman and Hanna (1935) from the upper Eocene of Venezuela, South America, and "*Robulus*" *mexicanus* (Cushman) var. *nudicostatus* (Cushman and G. D. Hanna) described by Cushman and McMasters (1936) from the middle Eocene, Llajas formation, of California.

We are indebted to Dr. H. G. Schenck of Stanford University for the loan of topotypes of *Marginulina mexicana* (Cushman), and to Doctor Cushman, for helpful criticism of the paper.

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